THE VERY LOW FREQUENCY (VLF) EMISSION TESTING OF CCOHS VIDEO DISPLAY TERMINALS

Canadian Centre for Occupational Health and Safety

Centre canadien d'hygiène et de sécurité au travail

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Hamilton Ontario Canada L8N 1H6

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THE VERY LOW FREQUENCY (VLF) EMISSION TESTING OF CCOHS VIDEO DISPLAY TERMINALS

BY

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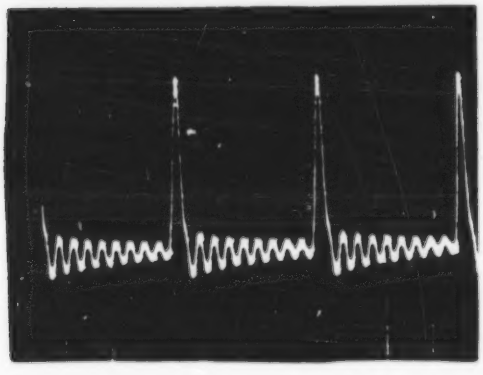
OBJECTIVES

1. To determine the magnitude of the very low frequency electric field around video display terminals used at CCOHS.

2. Where the field strength was found to be significantly above background, to determine if a simple, practical method exists to remove or isolate these fields from the area surrounding the unit.

INTRODUCTION

The "fly-back" transformer in the video display terminal is a source of pulsed very low frequency (VLF) radiation (see Fig. 1A). The fly-back transformer is part of the horizontal deflection and high voltage system which sweeps the electron beam across the face of the cathode ray tube (see Fig. 1B).



WAVEFORM OF 15.9 kHz PULSED FIELD

Fig. 1A

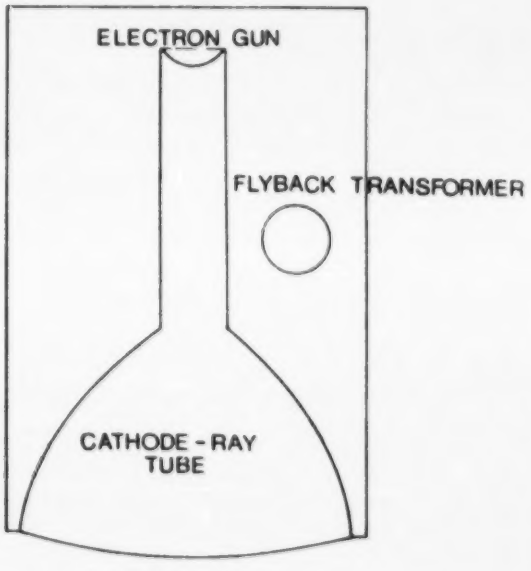


Fig. 1B

A high voltage (up to 25 kV) is necessary to accelerate the electrons from the electron gun. In order to achieve the correct beam deflection and high voltage, the horizontal output must be pulsed at a frequency corresponding to the product of the number of lines and the refresh rate, usually of the order of 15.9 kHz.

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This pulsating high voltage creates the pulsed VLF field, which is the subject of this study. There is some indication that the electric field waveform may be to a certain extent different depending upon the measurement location, for example front to back.

METHOD OF MEASUREMENT AND INSTRUMENTATION

The measurement of VLF fields was carried out at different distances, directions, and elevations from the unit.

A scale measuring angular degrees from 0 to 360 degrees (in 15 degree intervals) was constructed and centred on a swivel table. An elevation scale was erected measuring from -20 cm to +80 cm where 0 cm was the level of the base of the VDT. (See Fig. 2).

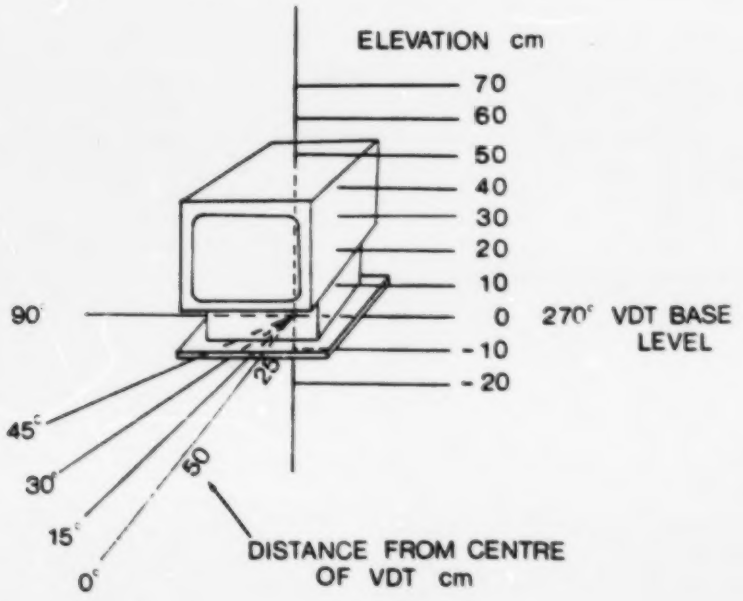

Fig. 2

The VDTs to be measured were placed on a swivel table with the vertical axis of the unit being the rotation axis.

Measurements of VLF electric field emissions were taken at elevations from -20 to +80 cm (from the base of the VDT) in 10 cm intervals. At each elevation readings were taken for distances from 0 to 80 cm which varied radially from the centre of the VDT. The interval of radial distance in the

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horizontal plane was 5 cm for radial distances up to 30cm from the centre of the unit and 10 cm thereafter. For each radial distance, measurements were taken around the VDT at various angles.

The operator's position directly in front of the screen was used as 0 degrees and the angular scale increased clockwise in 15 degree intervals around the unit. It should be noted that the front screen is 20 cm from the centre of the unit.

A marker was placed on the top of the unit to indicate its centre point. A string scaled in centimeters was placed with its origin at this centre point to measure the radial distance from the VDT in the horizontal plane.

The meter used was an IFI (Instruments for Industry) model EFS-1 Electric Field sensor which can measure the rms field strength from 1 V/m to 300 V/m. The shortest antenna (3/8" = 0.95 cm) was used to measure field strengths above 100 V/m. The longest antenna (5" = 12.7 cm) was used to measure field strengths up to 10 V/m and the medium-sized antenna (1" = 2.54 cm) was used to measure field strengths in the range from 10 V/m to 100 V/m. The frequency range of the meter is from 10 kHz to 200 MHz (broadbanding). It is important to note that at every measuring point the orientation of the meter was changed in such a way that the meter records the maximum field strength for each reading. It was found that maximal reading was with the antenna in the direction of the VDT unit.

CALIBRATION

The EFS-1 was calibrated for pulsed fields by Dr S M Harvey, Ontario Hydro research. Pulsed frequencies of 15 kHz and 20 kHz respectively were used, obtained from an HP3310B function generator.

It was found that with test fields, the errors were of the order of 10%. It may be estimated that with actual VDT fields which have more complex spatial and time variations, the errors will be somewhat higher but probably not more than 20% at distances of 5 cm or more.

Thus, the EFS-1 instrument can be used to measure the local "free space" electric fields around a VDT with satisfactory precision.

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RESULTS

At the time of measurement there were 25 Wang and 13 Hewlett-Packard terminals at CCOHS.

A. Wang Terminals

At a distance of 20 cm from the front of the screen (i.e. 40 cm from the centre of the VDT) the VLF field strength is less than 20 V/m.

For some units the maximum field is 10 V/m, at a distance of 20 cm from the surface of the ventilation opening on the left side of the terminal. Other units gave zero readings.

In other directions and above or below the unit no measurable fields were detected.

Removal of the cover on one of the Wang units revealed a metallic foil covering on the inside of the cabinet, which serves as a shield against VLF emissions.

B. Hewlett - Packard Terminals

There are two different types of Hewlett-Packard video display terminals in the building, HP-2621P and HP-2621A.

The "P" designates the inclusion of a printer in the unit. The printing mechanism is located on top of the unit. The "A" type is not equipped with a printer. Both terminals have the same physical dimensions.

Upon measuring the distribution of the VLF electric field around each unit, some differences were observed, as follows.

HP-2621P

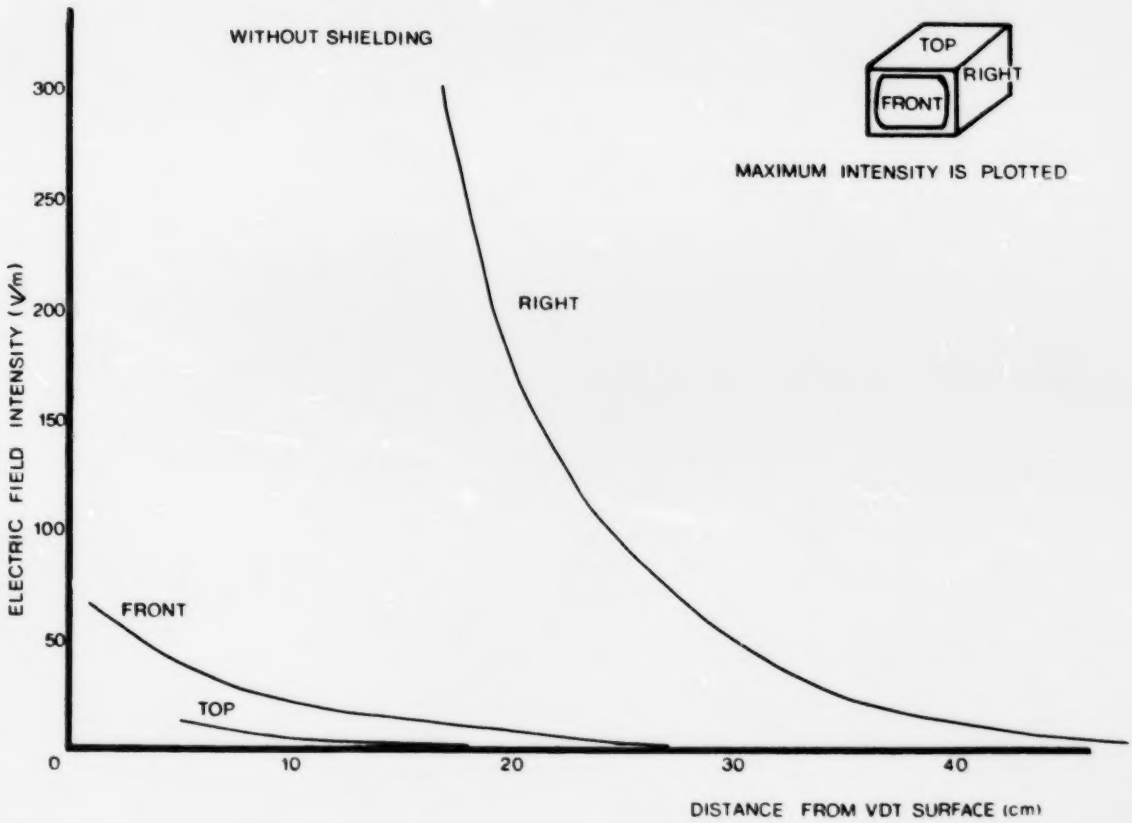
Emissions from the front of the screen were low; greater than zero levels (i.e. field strengths higher than the background level) were obtained up to 30 cm from the front of the screen. The maximum value obtained from the front screen area was 65 V/m (which was measured at the centre of the screen and at a distance of about 1 cm) but this value probably represents interference of the screen's electrostatic charge by the measuring probe and it cannot be accepted as a valid reading.

At a distance of 10 cm from the screen, a maximum reading of 22 V/m was observed.

The right side of the HP-2621P model was found to have relatively strong emissions. Measurements of a magnitude greater than 300 V/m (limit of the upper scale on the meter) were recorded up to 17 cm from the right side of the unit (near the rear). These were the highest levels found anywhere around the VDT. The measurements decreased to 90 V/m at a distance of 25 cm from the right side of the unit.

Greater-than-zero readings were recorded from the right side near the rear up to 20 cm above and below the unit. The maximum at these areas were 40 V/m (10 cm above the right side) and 25 V/m (10 cm below the right side).

The maximum values of electric field intensity from the top front and right side of the HP-2621P are plotted in Fig. 3.



VLF ELECTRIC FIELD INTENSITY
VERSUS DISTANCE FROM HEWLETT-PACKARD HP-2621P VDT

Fig. 3

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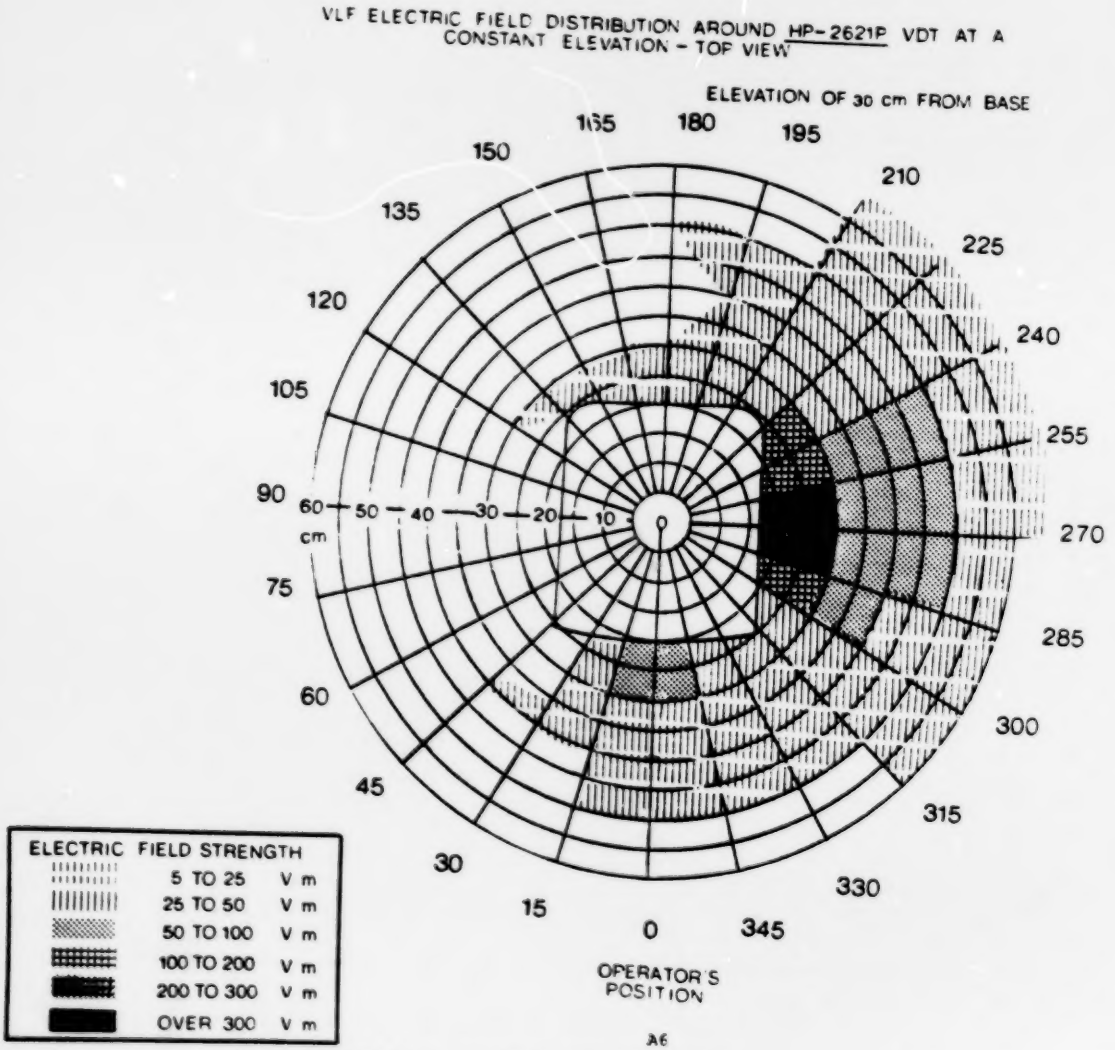
Examples of the cross-sectional views in both the horizontal plane and vertical plane are given in Fig. 4 and Fig. 5. Detailed sketches of the VLF field distribution around the HP-2621P are found in Appendix A. The first set of sketches (A1 to A10) are top-view cross-sections taken at elevations from -20 cm to +70 cm which reveal the VLF field distribution at the various elevations. The second set of sketches (A11 to A17)are cross-sections in the vertical plane showing the VLF field distribution around the HP-2621P.



VLF ELECTRIC FIELD DISTRIBUTION AROUND HP-2621P VDT AT A CONSTANT ELEVATION - TOP VIEW

Fig. 4

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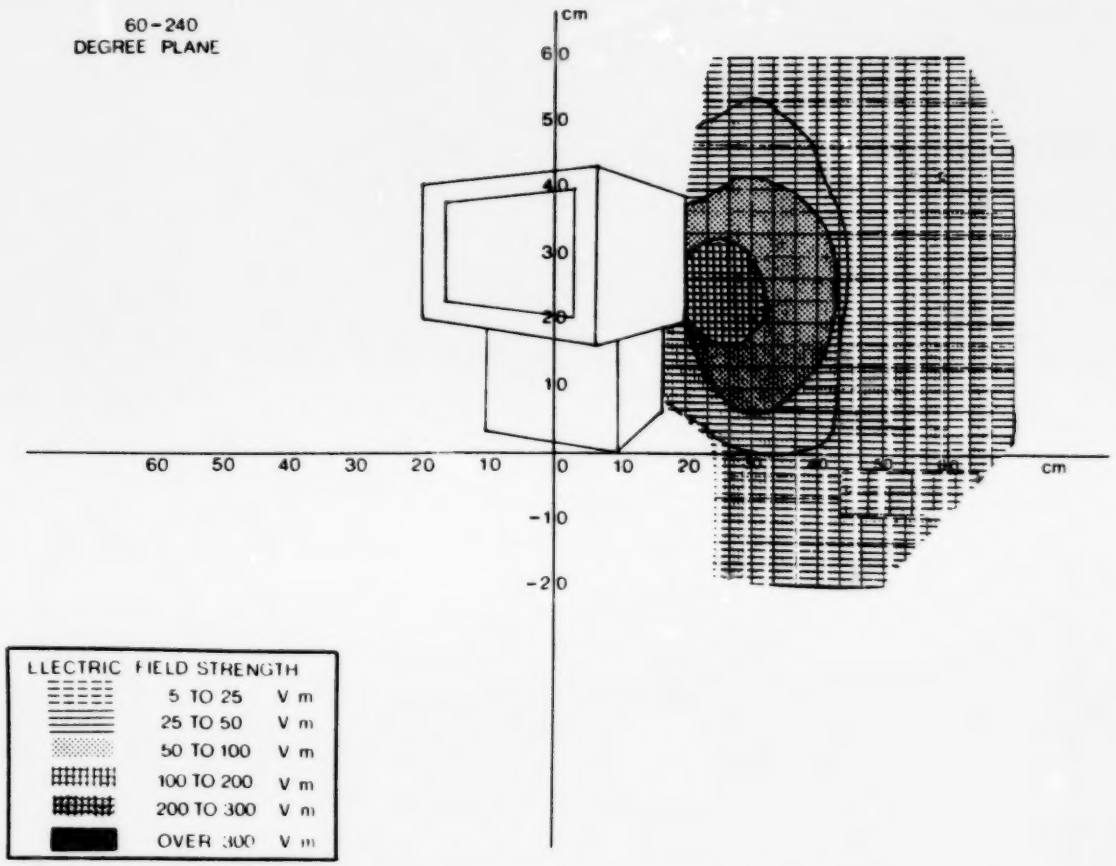

VLF ELECTRIC FIELD DISTRIBUTION ABOUT
HEWLETT-PACKARD HP-2621P VIDEO DISPLAY TERMINAL

Fig. 5

HP-2621A

The front screen area of the HP-2621A was found to have approximately the same VLF electric field emission as the HP-2621P, although the right-hand side of the HP-2621A was found to have slightly greater readings.

The maximum readings were greater than 300 V/m, measured up to 20 cm from the right side of the video display terminal. Emissions decreased greatly above 20 cm and were negligible at 50 cm from the surface of the VDT.

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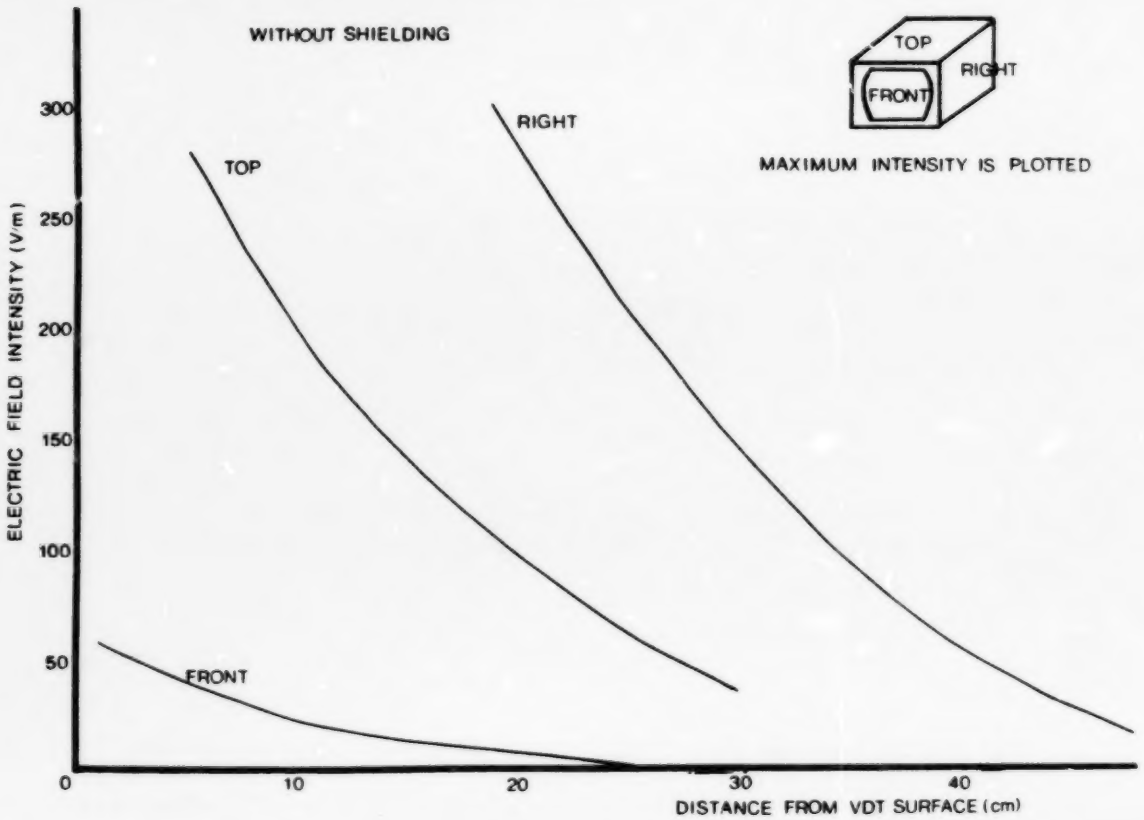
Higher readings than the HP-2621P were also obtained on the top of the HP-2621A. The largest value measured was 290 V/m on the top right side of the unit. The field strength decreased towards the left side and above the VDT. Negligible readings were recorded 10 cm above the HP-2621A on the entire left side. A maximum of 65 V/m was measured 10 cm below the right side of the base. The field decreased below that area. Negligible strengths were measured below, beside and above the left side of the HP-2621A.

The maximum values of VLF field intensity from the top, front, and right side of the HP-2621A are plotted in Fig. 6.



VLF ELECTRIC FIELD INTENSITY VERSUS
DISTANCE FROM HEWLETT-PACKARD HP-2621A VDT

Fig. 6

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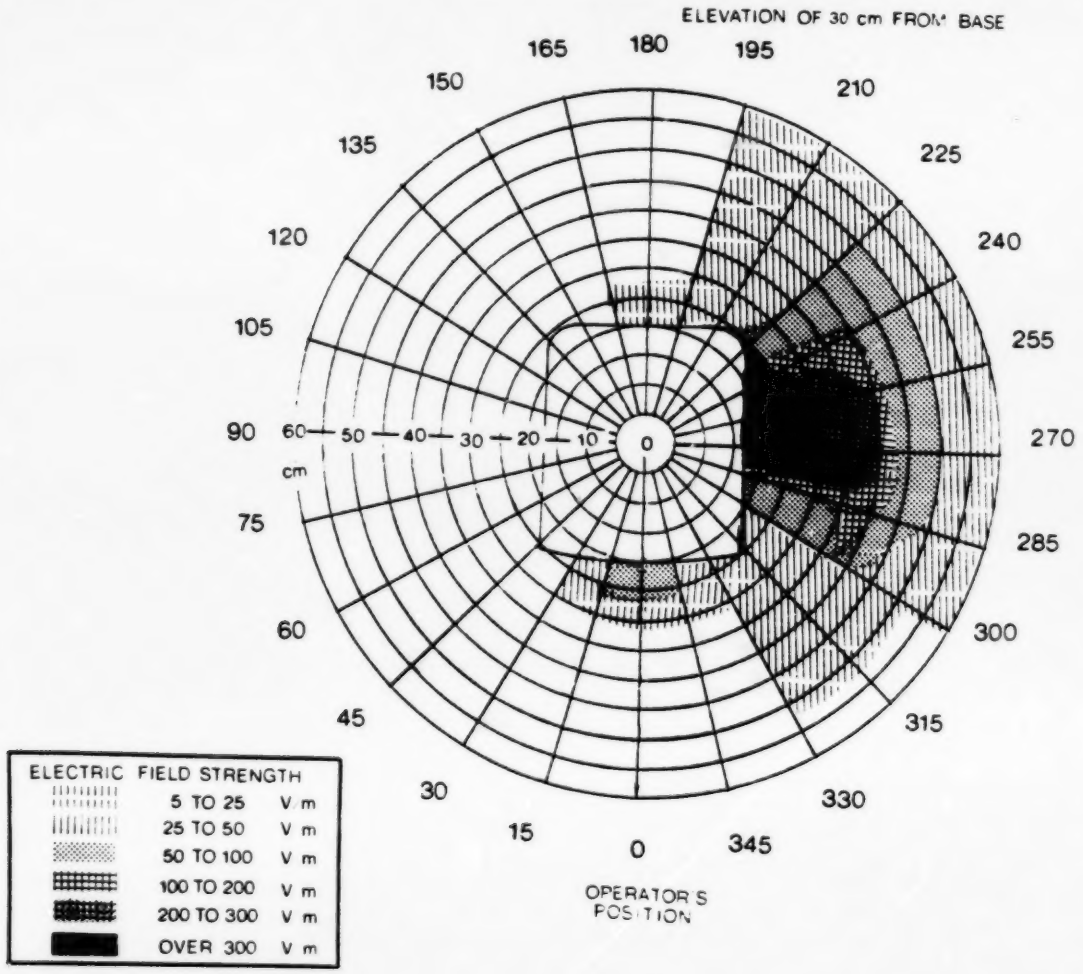
Similar to those for the HP-2621P, sketches for the HP-2621A are given in Appendix B. Cross-sections in the horizontal plane are given on pages B1 to B10. Cross-sections in the vertical plane are found on pages B11 to B17. Examples of these cross-sections (in the vertical plane and in the horizontal plane) are shown in Fig. 7 and Fig. 8.

VLF ELECTRIC FIELD DISTRIBUTION AROUND HP-2621A VDT AT A CONSTANT ELEVATION - TOP VIEW



VLF ELECTRIC FIELD DISTRIBUTION AROUND HP-2621A VDT AT A CONSTANT ELEVATION - TOP VIEW

Fig. 7

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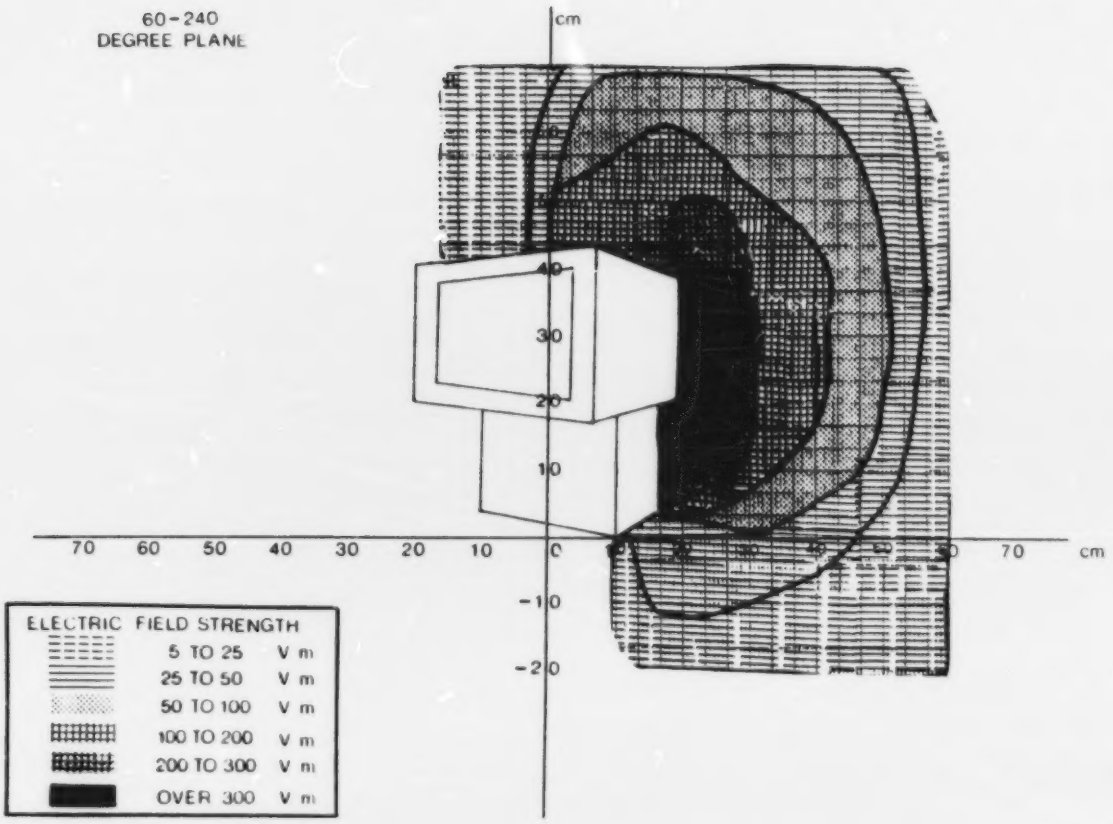

VLF ELECTRIC FIELD DISTRIBUTION
ABOUT HEWLETT-PACKARD HP-2621A VDT

Fig. 8

In both the HP-2621A and HP-2621P, there are measureable emissions in front (but negligible at 30 cm distance from the screen) and especially on the right hand side. The maximum intensity of the VLF fields around the Hewlett-Packard terminals is summarized in Table 1.

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MAXIMUM INTENSITY OF VLF ELECTRIC FIELD OF VARIOUS VDTS IN CCOHS

TABLE 1

Model: HP-2621P

		V/m			
		10 cm From	Close to		
Location	Serial #	Screen	Sides	Top	Rear
Rm 114	1932A03223	22	300+	15	30
Rm 120	1942A10037	22	300+	15	30
Rm 120	1912AO3185	21	300+	15	30
Computer Rm	1912AO1667	22	300+	15	30
Training Rm	1932AO3624	24	300+	15	30
Training Rm	2152V17337	23	300+	15	30
Rm 327	1912AO3190	22	300+	15	30
Rm 316	1942AO9804	21	300+	15	30
Rm 429	2023WO0067	20	300+	15	30

Model: HP-2621A

		V/m			
		10 cm From	Close to		
Location	Serial #	Screen	Sides	Top	Rear
Mail Rm	2118V12565	22	300+	290	40
Computer Rm	2118V12560	21	300+	290	40
Rm 431	2118V12566	22	300+	290	40
Rm 431	2118V12567	21	300+	290	40

300+ = greater than 300 V/m

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The area having greater-than-zero readings on the right side of the HP-2621A is larger than that from the HP-2621P. The HP-2621A also has measureable emissions on the top right side of the unit. A comparison of the VLF emissions from all types of video display terminals used in CCOHS is given in Table 2.

TABLE 2

MAXIMUM INTENSITY OF VLF ELECTRIC FIELD AT VARIOUS LOCATIONS AROUND THE VDT FOR VARIOUS MODELS (V/m)

		V/m MODEL		
LOCATION	DISTANCE FROM UNIT (cm)	WANG	HP-2621P	HP2621A
Screen	1	-	65	60
	10	-	22	22
	30	20V/m	0	0
Sides	5	-	300+ (R)	300+ (R)
	20	10V/m(L)	180 (R)	300+ (R)
	35	0	25 (R)	100 (R)
Back	5	0	30	40
	15	0	0	0
Top	5	0	15	270
	25	0	0	60

- = no data
L = left side of unit
R = right side of unit
300+ = greater than 300 V/m

NOTE: It should be noted that there are no existing standards in Canada for maximum permissible exposure levels for electromagnetic emissions in the frequency range below 300 kHz.

Some standards covering the maximum permissible field strengths in the very low and low frequency range are given in Table 3. However, the discussion of possible biological effects of pulsed very low frequencies and their threshold is not a goal of this report.

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TABLE 3

Some standards covering the very low frequency or the low frequency range.

U.S. Air Force	10kHz	-	10MHz	435V/m
ACGIH	10kHz	-	3MHz	600V/m**
Czechoslovakia	30kHz	-	30MHz	50V/m*
USSR	60kHz	-	3MHz	50V/m*
Bulgaria	60kHz	-	3MHz	50V/m*
German Democratic Republic	60kHz	-	3MHz	50V/m*
Canada (Ontario)	300kHz	-	300GHz	60V/m***
ANSI	300kHz	-	3MHz	600V/m**

Notes: * Standards in the workplace. The values for general public are often even more stringent (e.g. in Czechoslovakia, for 8 hours it is 15V/m).

** At a distance of 5 cm from any point on the device's surface.

*** 'For discussion only' guideline

ANSI American Standards Institute (Approved as an American National Standard on July 30, 1982).

ACGIH American Conference of Governmental Industrial Hygienists.

Extracted from:

Martha, K. The state of knowledge concerning radiations from video display terminals. The CCOHS identification numbers are A82-4E for English and A82-4F for French. (Presented at Science Focus, Ottawa, Ontario on October 6, 1982). Hamilton, Ont.: CCOHS 1982.

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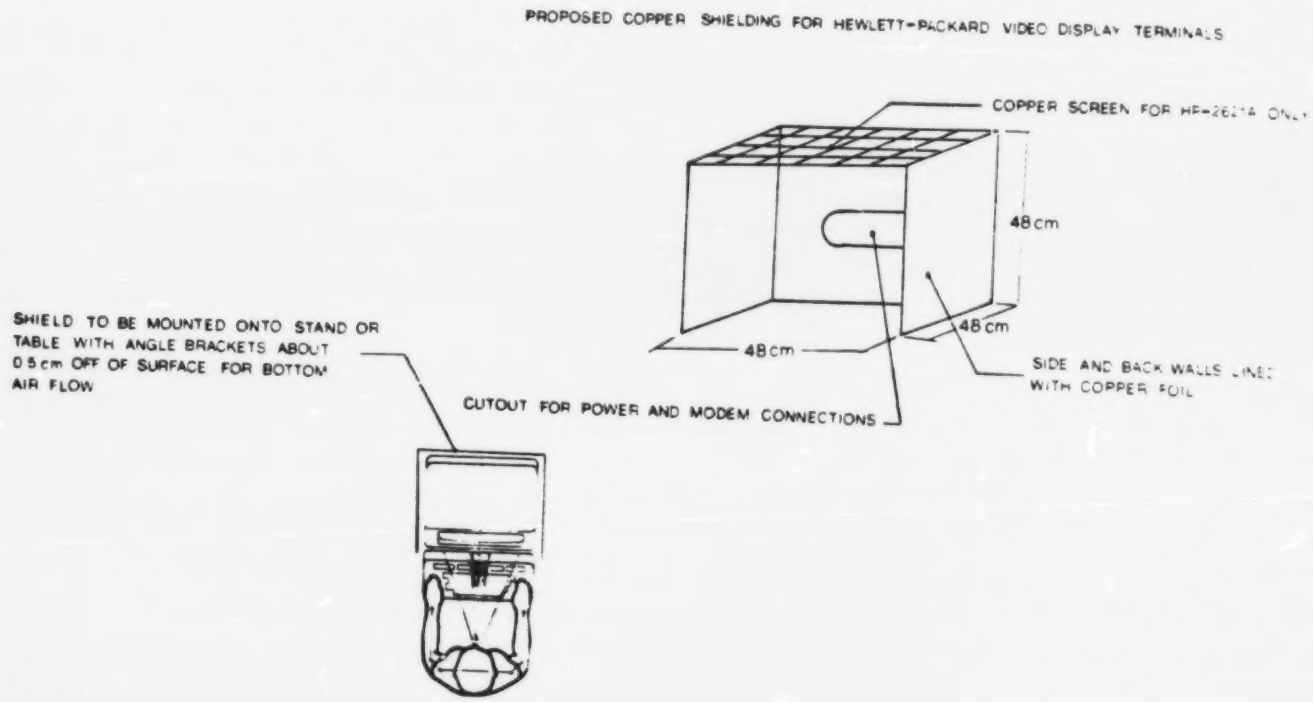
SHIELDING

It would have been best to shield the flyback transformer to reduce the electric field emissions in all directions. However, our goal was not to change the design of the unit. Therefore, we used external shielding. A practical method of removing the VLF electric field emissions was developed and tested. Fig. 9 illustrates this method of shielding the Hewlett-Packard video display terminals. In our experiment, the walls of the shielding (made of plywood) were lined with copper foil* and a grounding wire was soldered to it. This grounding wire can be placed around a metal screw on the modem cable (Fig. 10), since the modem cable is shielded and this shielding is connected to the video display terminal main ground.


PROPOSED COPPER SHIELDING FOR HEWLETT-PACKARD VIDEO DISPLAY TERMINALS
COPPER SCREEN FOR HP-2621A ONLY
48 cm
48 cm
48 cm
SIDE AND BACK WALLS LINED WITH COPPER FOIL
SHIELD TO BE MOUNTED ONTO STAND OR TABLE WITH ANGLE BRACKETS ABOUT 0.5 cm OFF OF SURFACE FOR BOTTOM AIR FLOW
CUTOUT FOR POWER AND MODEM CONNECTIONS
COPPER SCREEN AND FOIL GROUNDED TO INCOMING METAL CONNECTORS

PROPOSED COPPER SHIELDING FOR
HEWLETT-PACKARD VIDEO DISPLAY TERMINALS

Fig. 9

NOTE: The copper foil can be obtained from Paisley Products of Canada, Inc., 40 Upton Road, Scarborough, Ontario, M1L 2B8. It should be noted that any conducting metal, (aluminum foil for example) would serve as a shield.

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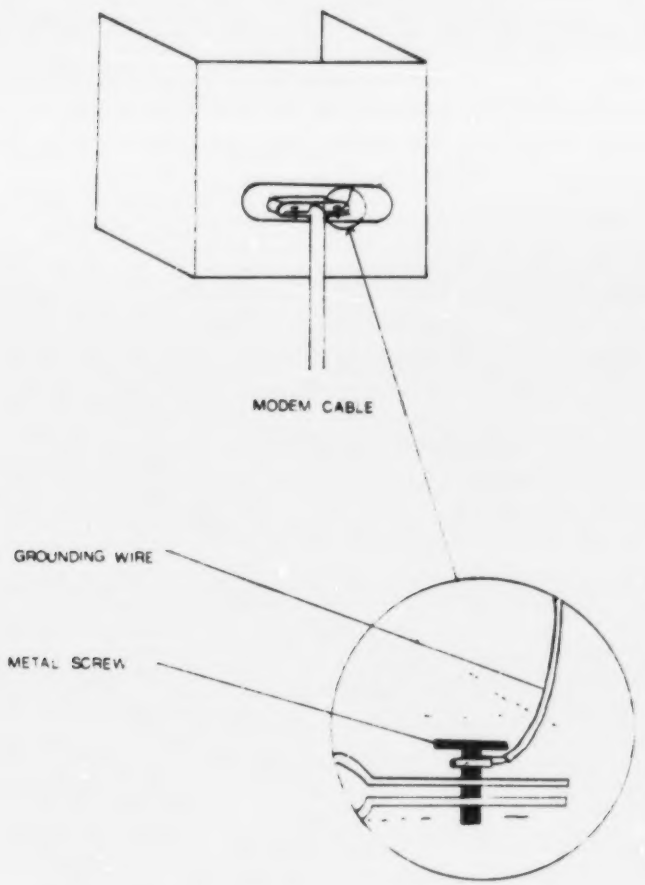

CONNECTION OF GROUNDING WIRE FROM COPPER SCREEN AND FOIL TO METAL SCREW ON INCOMING MODEM CABLE

Fig. 10

For the HP-2621A video display terminal, copper screening* was used to shield the top of the unit. The screen was used instead of foil in order to allow proper air flow (since the ventilation is located on top of the unit). Shielding is not practical on the top of the HP-2621P because of the printer, but fortunately, it is not necessary because the printer acts as a shield. Photographs of the shielding used in our experiment can be found in Appendix C.

NOTE: The copper screen can be obtained from Greening Donald Co., Ltd., P.O. Box 430, Hamilton, Ontario, L8N 3J3.

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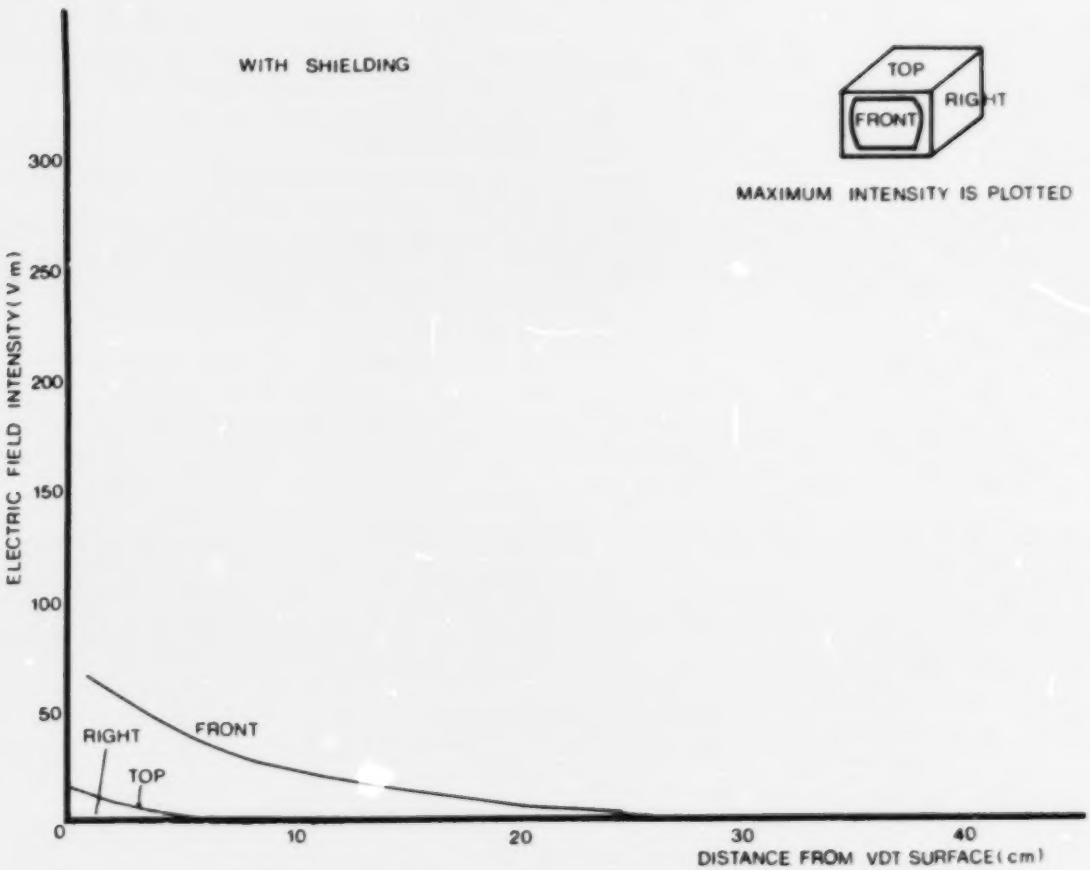
The effect of this shielding on the VLF field around the VDTs is plotted in Fig. 11 and Fig. 12. From these, it can be seen that with the use of shielding, the VLF emissions on the right side are reduced to zero, whereas the emissions from the front screen are unaffected.



EFFECT OF SHIELDING ON VLF ELECTRIC FIELD INTENSITY VERSUS DISTANCE FROM HEWLETT-PACKARD HP-2621P VDT (COMPARE WITH FIG. 3)

Fig. 11

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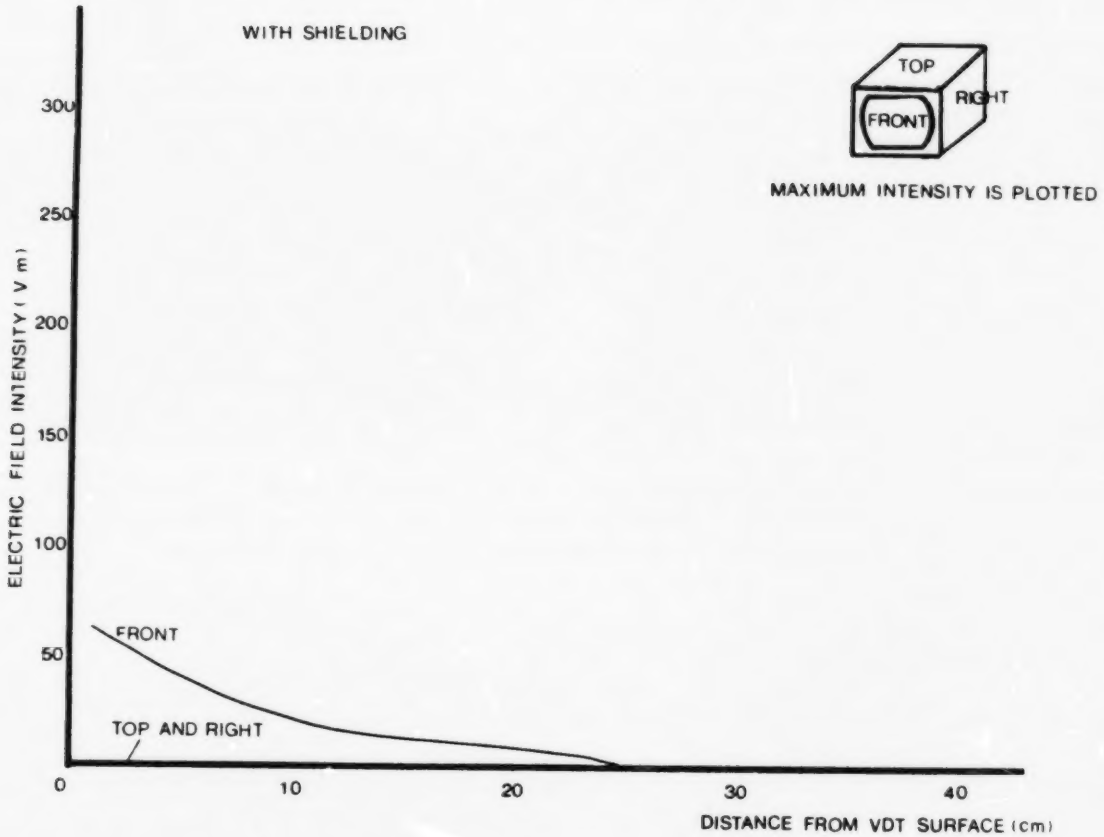

EFFECT OF SHIELDING ON VLF ELECTRIC FIELD INTENSITY VERSUS DISTANCE FROM HEWLETT-PACKARD HP-2621A VDT (COMPARE WITH FIG. 6)

Fig. 12

It should be noted that even without the ground wire connection, the VLF field is reduced to less than 10V/m (on the right side).

Various materials were evaluated as shielding medium (see footnote p. 14) and since there has been much interest in the use of lead aprons for VDT operators, they were included in the testing.

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It was found that the lead apron had no measureable effect on the VLF electric field emissions from the flyback transformer. The use of the lead apron did not result in the absorption or reflection of the VLF emissions. Lead aprons, as used in medical offices, are meant to protect only against penetrating x-radiation, lead being a very good X-ray shielding substance. The lead apron provided no protection against VLF electric field emissions because the lead is there as a compound rather than in metallic form.

SUMMARY AND CONCLUSIONS

A. All Wang terminals at the CCOHS which were tested appear to have extremely low VLF fields, regardless of type, model or year. The units at the CCOHS are already shielded inside by the manufacturer. The reason for this shielding is unknown to us.

B. The VLF field in front of the screen of Hewlett-Packard terminals is so low that the exposure of the operator is close to zero. Significant values of VLF electric field intensity above background were found on the right side of the unit where the fly-back transformer is located. The measured differences in the distribution of VLF emissions from the HP-2621P and HP-2621A probably occur due to the shielding provided by the printer module in the HP-2621P.

C. An example of possible shielding was tested around the Hewlett-Packard terminals and it was found that its use resulted in greatly reduced VLF emissions around the unit. It is important to note, however, that the emissions from the front screen were unaffected by the shielding.

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ACKNOWLEDGEMENT

We acknowledge the technical assistance of Joyce Turner, Bev Strugnell, Gary Spencer, and Reinhard Hass from CCOHS.

Extended thanks go to Dr S M Harvey, Engineer/Physicist, Electrical Research Department, Ontario Hydro, Mr Brian G Phillips, Program Manager, Industrial Special Applications, Radiation Health Branch, Alberta Workers' Health, Safety and Compensation and Mr Richard A Tell, Chief, Non-ionizing Radiation Branch, U.S. Environmental Protection Agency, for their helpful suggestions and recommendations on the draft version.

We wish to give special thanks to Dr John L Sullivan, Professor of Environment Engineering, Faculty of Engineering Science, Occupational Health and Safety Resource Centre at the University of Western Ontario, London, for lending us the measuring equipment.

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APPENDICES

Cross-sectional View of VLF Emissions	
Horizontal Plane - HP2621P	A1 to A10
Vertical Plane - HP2621P	A11 to A17
Cross-sectional View of VLF Emissions	
Horizontal Plane - HP2621A	B1 to B10
Vertical Plane - HP2621A	B11 to B17
Photographs of Experimental Shielding	C

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CROSS-SECTIONAL VIEW OF VLF EMISSIONS

HORIZONTAL PLANE - HP2621P

A1 to A10

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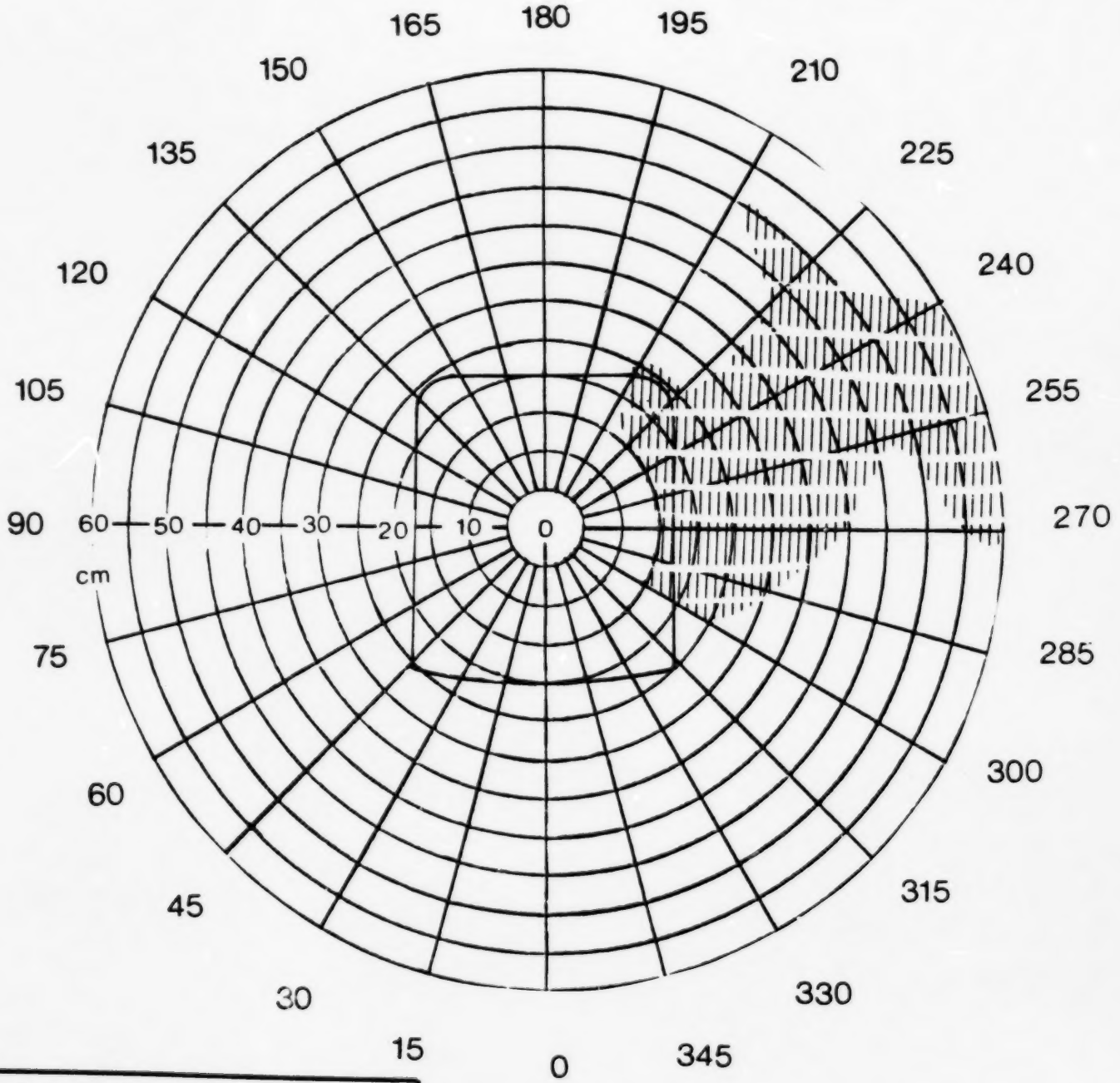
VLF ELECTRIC FIELD DISTRIBUTION AROUND HP-2621P VDT AT A CONSTANT ELEVATION - TOP VIEW

ELEVATION OF - 20cm FROM BASE



ELECTRIC FIELD STRENGTH

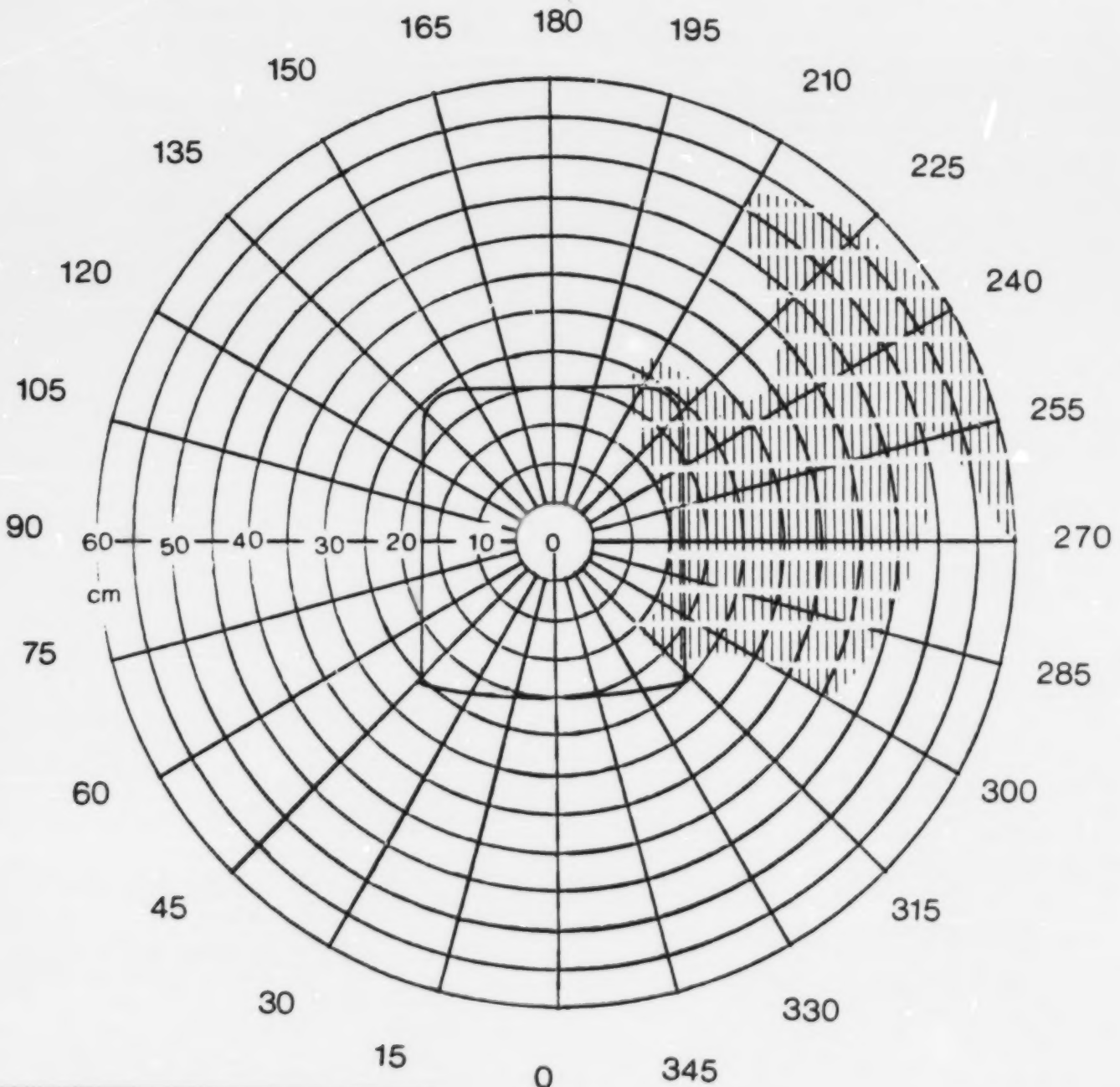
5 TO 25	V/m
25 TO 50	V m
50 TO 100	V m
100 TO 200	V m
200 TO 300	V/m
OVER 300	V/m

OPERATOR'S POSITION

CCOHS/CCHST
250 Main Street E./250 rue Main est.
Hamilton, Ontario, Canada L8N 1H6

VLF ELECTRIC FIELD DISTRIBUTION AROUND HP-2621P VDT AT A CONSTANT ELEVATION - TOP VIEW

ELEVATION OF-10 cm FROM BASE

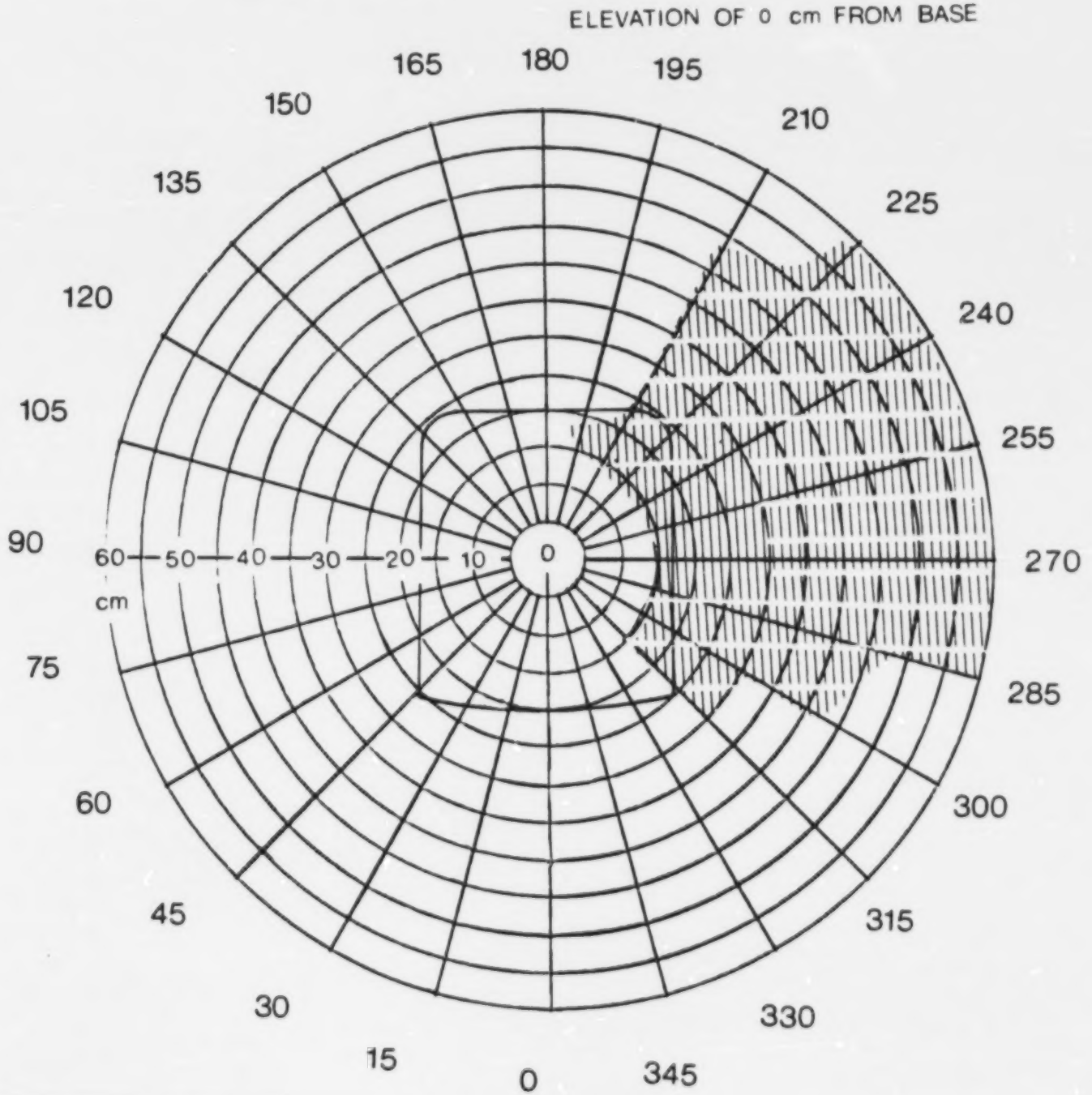


ELECTRIC FIELD STRENGTH

5 TO 25	V/m
25 TO 50	V m
50 TO 100	V m
100 TO 200	V m
200 TO 300	V m
OVER 300	V/m

CCOHS/CCHST
250 Main Street E./250 rue Main est
Hamilton, Ontario, Canada L8N 1H6

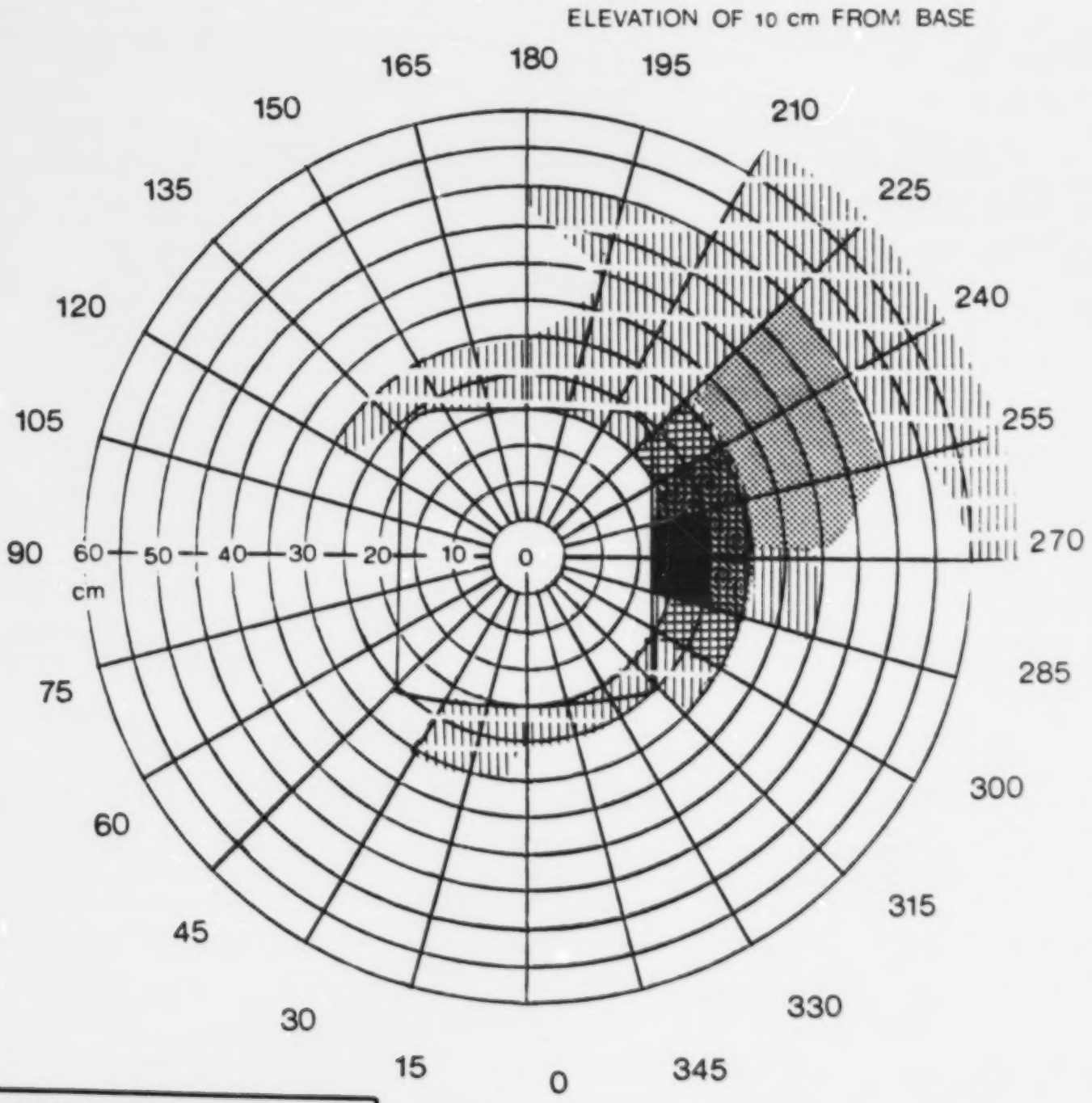
VLF ELECTRIC FIELD DISTRIBUTION AROUND HP-2621P VDT AT A CONSTANT ELEVATION - TOP VIEW



ELECTRIC FIELD STRENGTH		
	5 TO 25	V/m
	25 TO 50	V/m
	50 TO 100	V/m
	100 TO 200	V/m
	200 TO 300	V/m
	OVER 300	V/m

CCOHS/CCHST
250 Main Street E./250 rue Main est
Hamilton, Ontario, Canada L8N 1H6

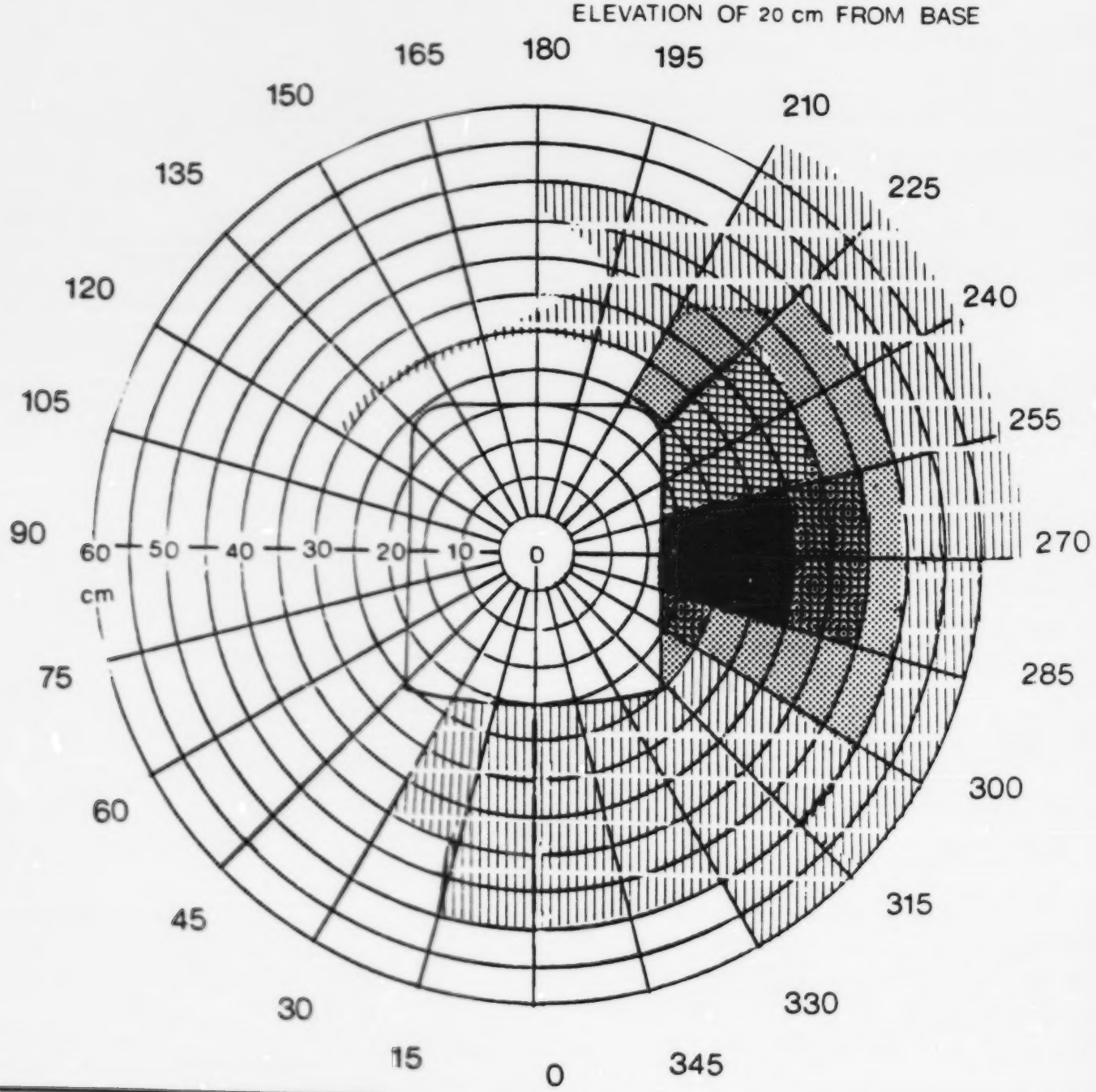
VLF ELECTRIC FIELD DISTRIBUTION AROUND HP-2621P VDT AT A CONSTANT ELEVATION - TOP VIEW



ELECTRIC FIELD STRENGTH		
	5 TO 25	V/m
	25 TO 50	V m
	50 TO 100	V m
	100 TO 200	V m
	200 TO 300	V m
	OVER 300	V m

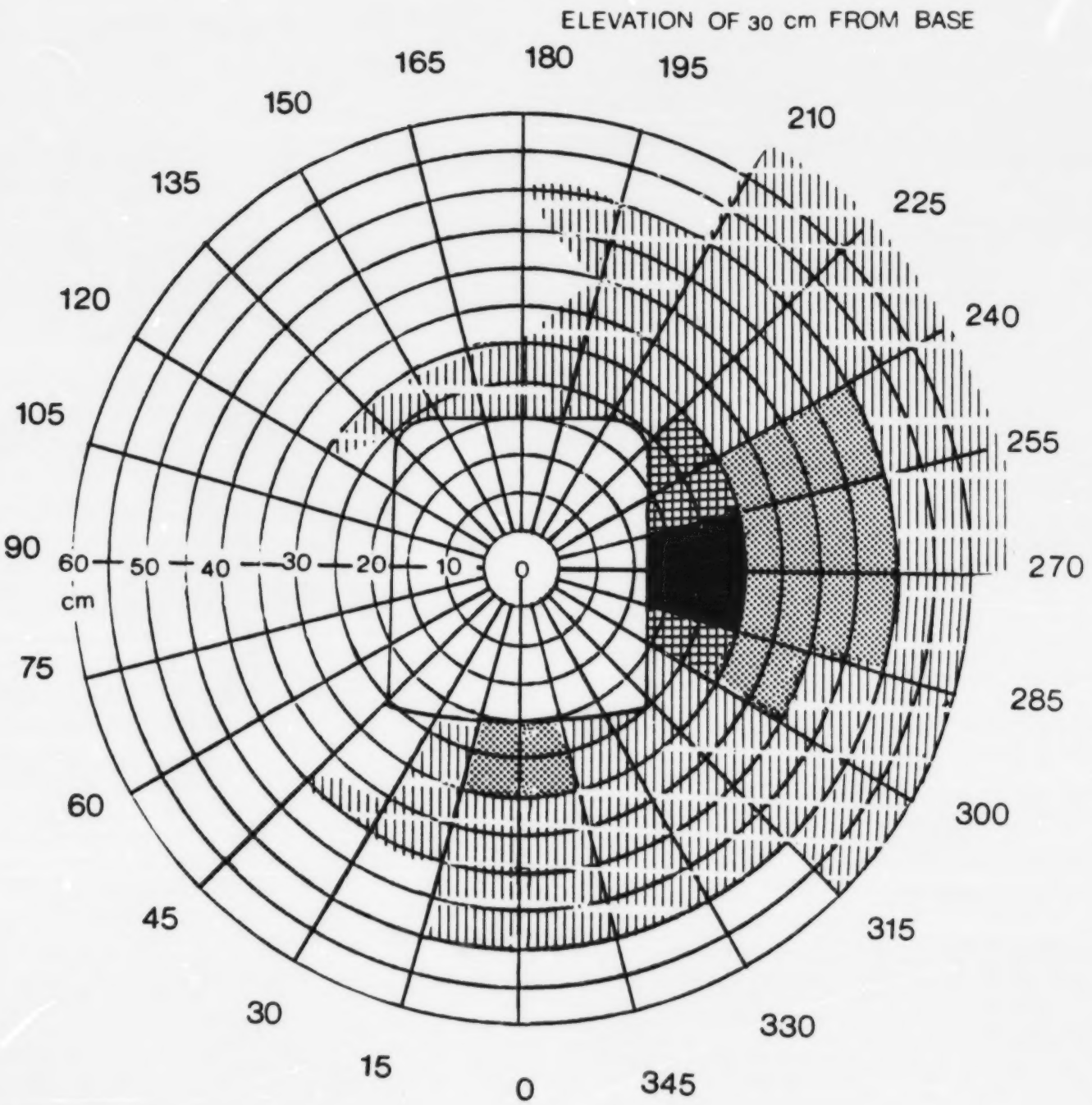
CCOHS/CCHST
250 Main Street E./250 rue Main est
Hamilton, Ontario, Canada L8N 1H6

VLF ELECTRIC FIELD DISTRIBUTION AROUND HP-2621P VDT AT A CONSTANT ELEVATION - TOP VIEW



CCOHS/CCHST
250 Main Street E./250 rue Main est.
Hamilton, Ontario, Canada L8N 1H6

VLF ELECTRIC FIELD DISTRIBUTION AROUND HP-2621P VDT AT A CONSTANT ELEVATION - TOP VIEW

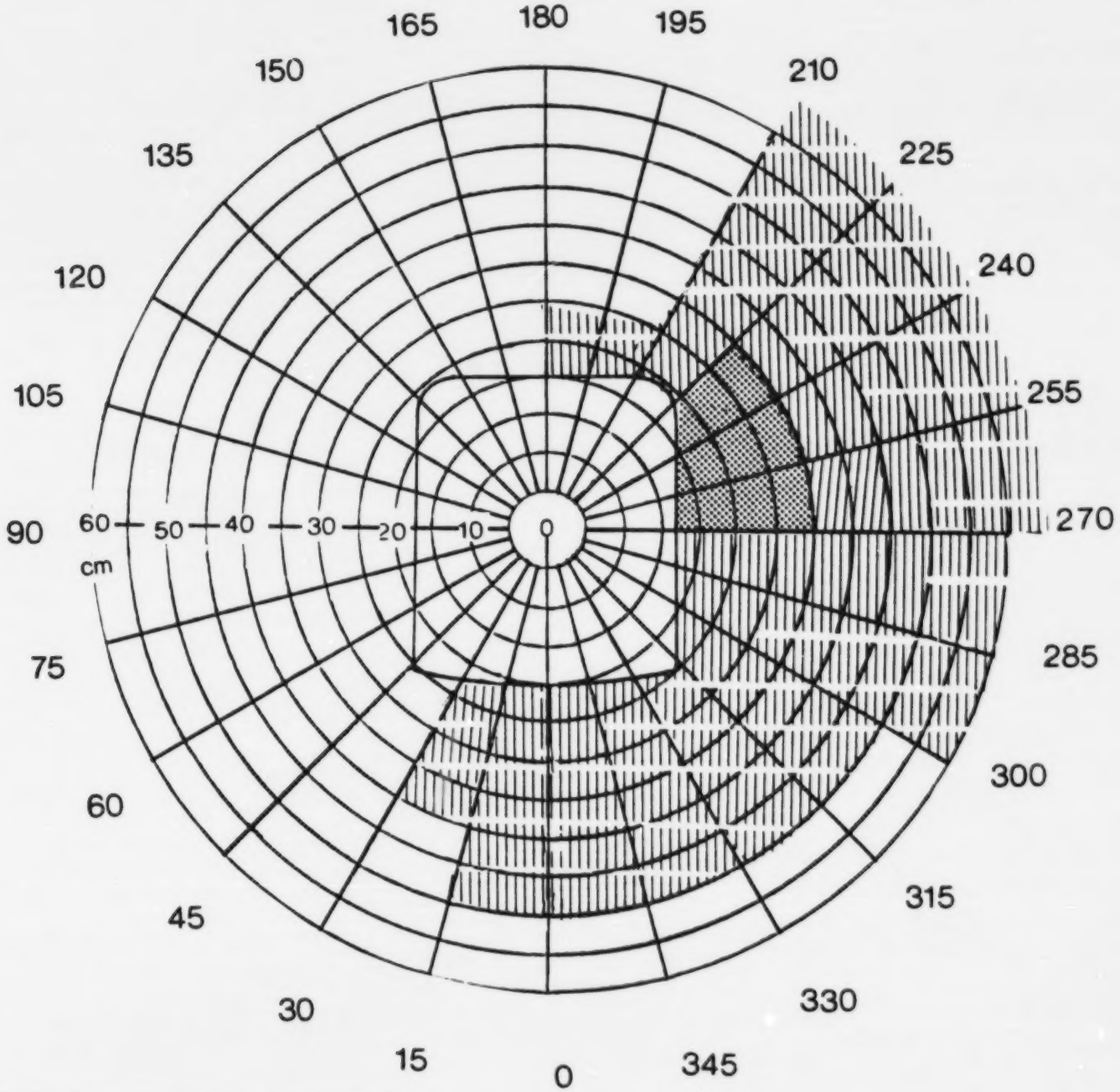


ELECTRIC FIELD STRENGTH		
	5 TO 25	V/m
	25 TO 50	V m
	50 TO 100	V m
	100 TO 200	V m
	200 TO 300	V m
	OVER 300	V/m

CCOHS/CCHST
250 Main Street E./250 rue Main est.
Hamilton, Ontario, Canada L8N 1H6

VLF ELECTRIC FIELD DISTRIBUTION AROUND HP-2621P VDT AT A CONSTANT ELEVATION - TOP VIEW

ELEVATION OF 40 cm FROM BASE



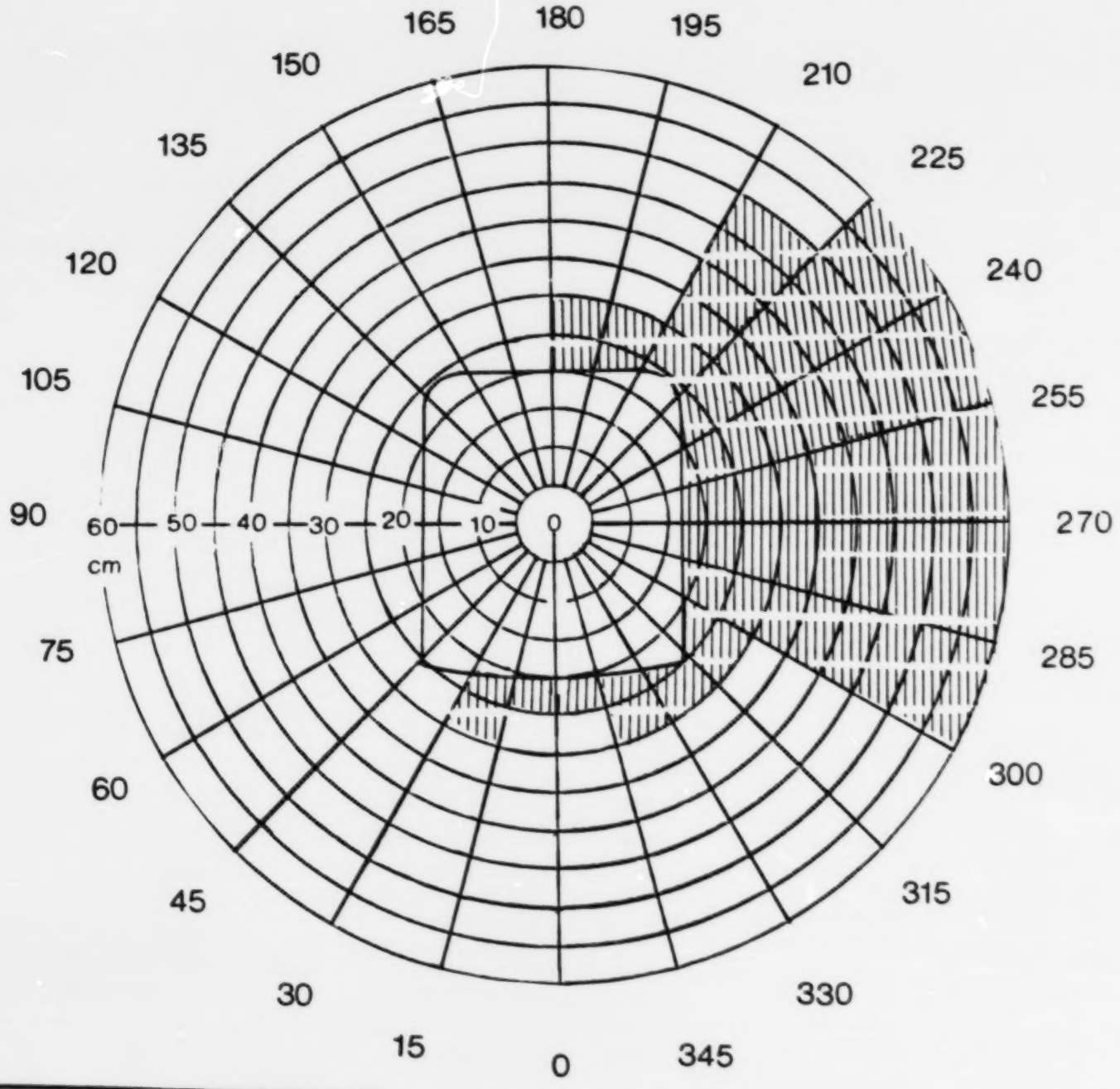
ELECTRIC FIELD STRENGTH

5 TO 25	V/m
25 TO 50	V m
50 TO 100	V m
100 TO 200	V m
200 TO 300	V m
OVER 300	V/m

CCOHS/CCHST
250 Main Street E./250 rue Main est.
Hamilton, Ontario, Canada L8N 1H6

VLF ELECTRIC FIELD DISTRIBUTION AROUND HP-2621P VDT AT A CONSTANT ELEVATION - TOP VIEW

ELEVATION OF 50 cm FROM BASE

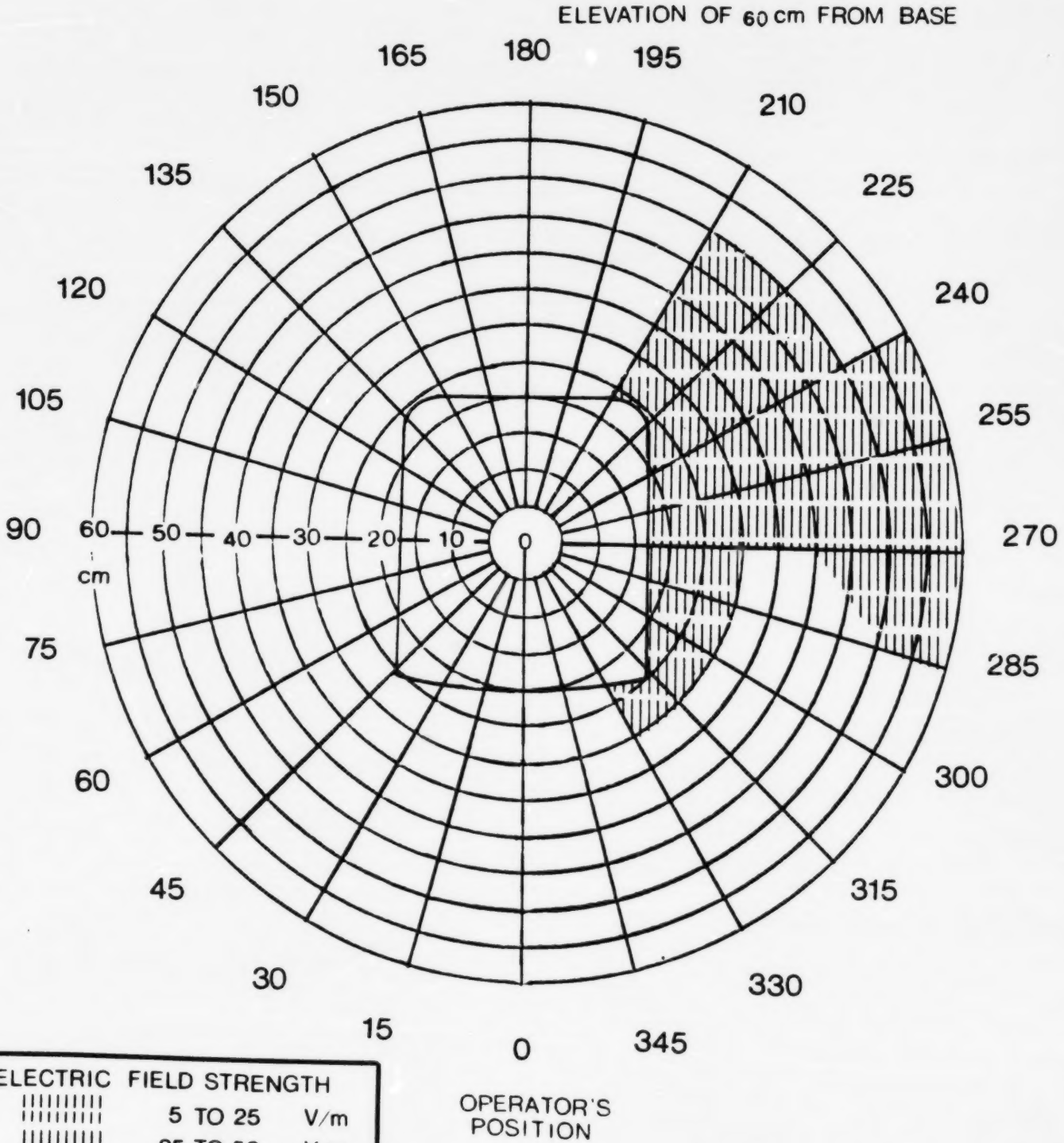


ELECTRIC FIELD STRENGTH

5 TO 25	V/m
25 TO 50	V m
50 TO 100	V m
100 TO 200	V m
200 TO 300	V m
OVER 300	V/m

CCOHS/CCHST
250 Main Street E./250 rue Main est
Hamilton, Ontario, Canada L8N 1H6

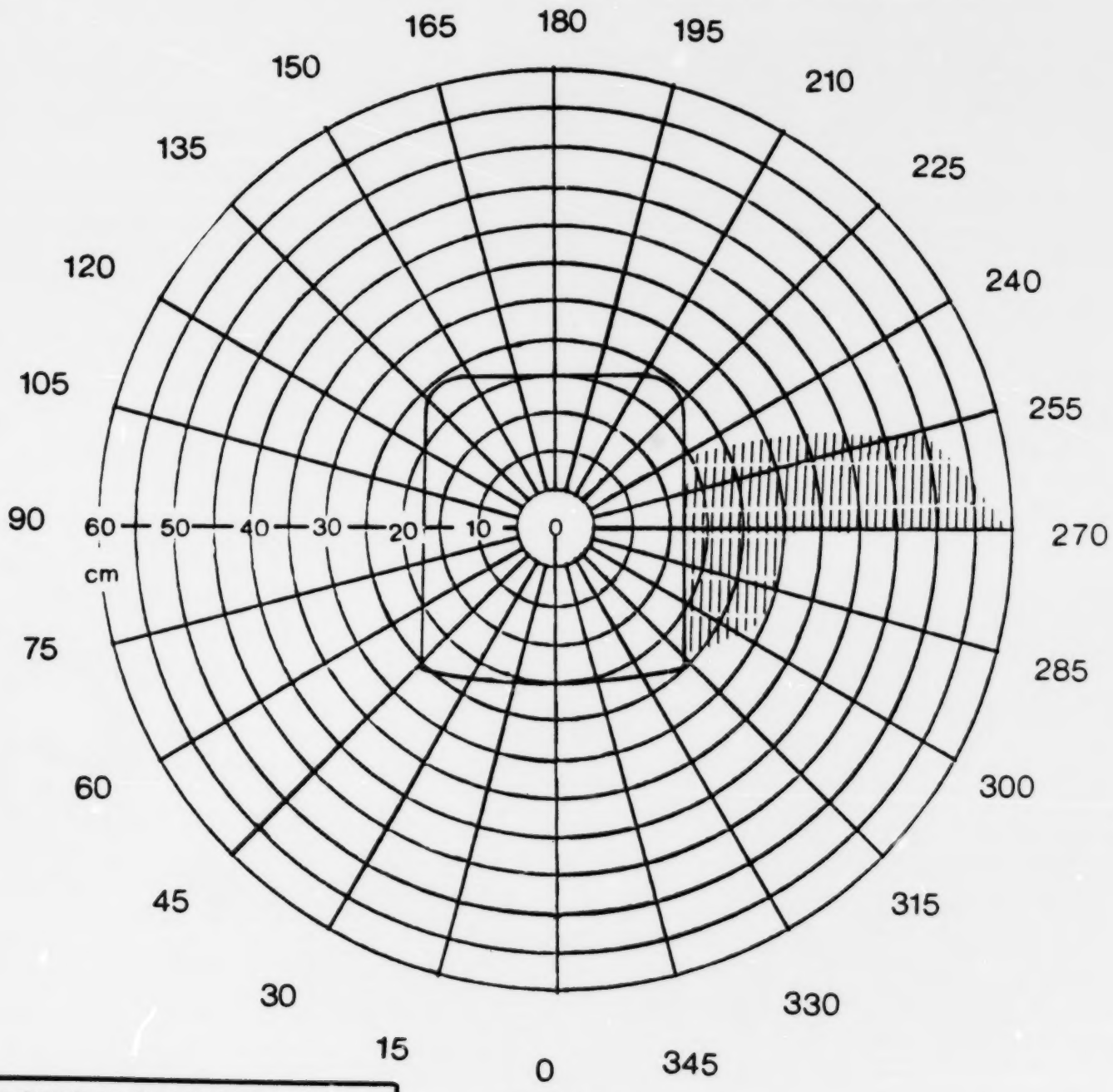
VLF ELECTRIC FIELD DISTRIBUTION AROUND HP-2621P VDT AT A CONSTANT ELEVATION - TOP VIEW



CCOHS/CCHST
250 Main Street E./250 rue Main est.
Hamilton, Ontario, Canada L8N 1H6

VLF ELECTRIC FIELD DISTRIBUTION AROUND HP-2621P VDT AT A CONSTANT ELEVATION - TOP VIEW

ELEVATION OF 70 cm FROM BASE



ELECTRIC FIELD STRENGTH

5 TO 25	V/m
25 TO 50	V/m
50 TO 100	V/m
100 TO 200	V/m
200 TO 300	V/m
OVER 300	V/m

OPERATOR'S POSITION

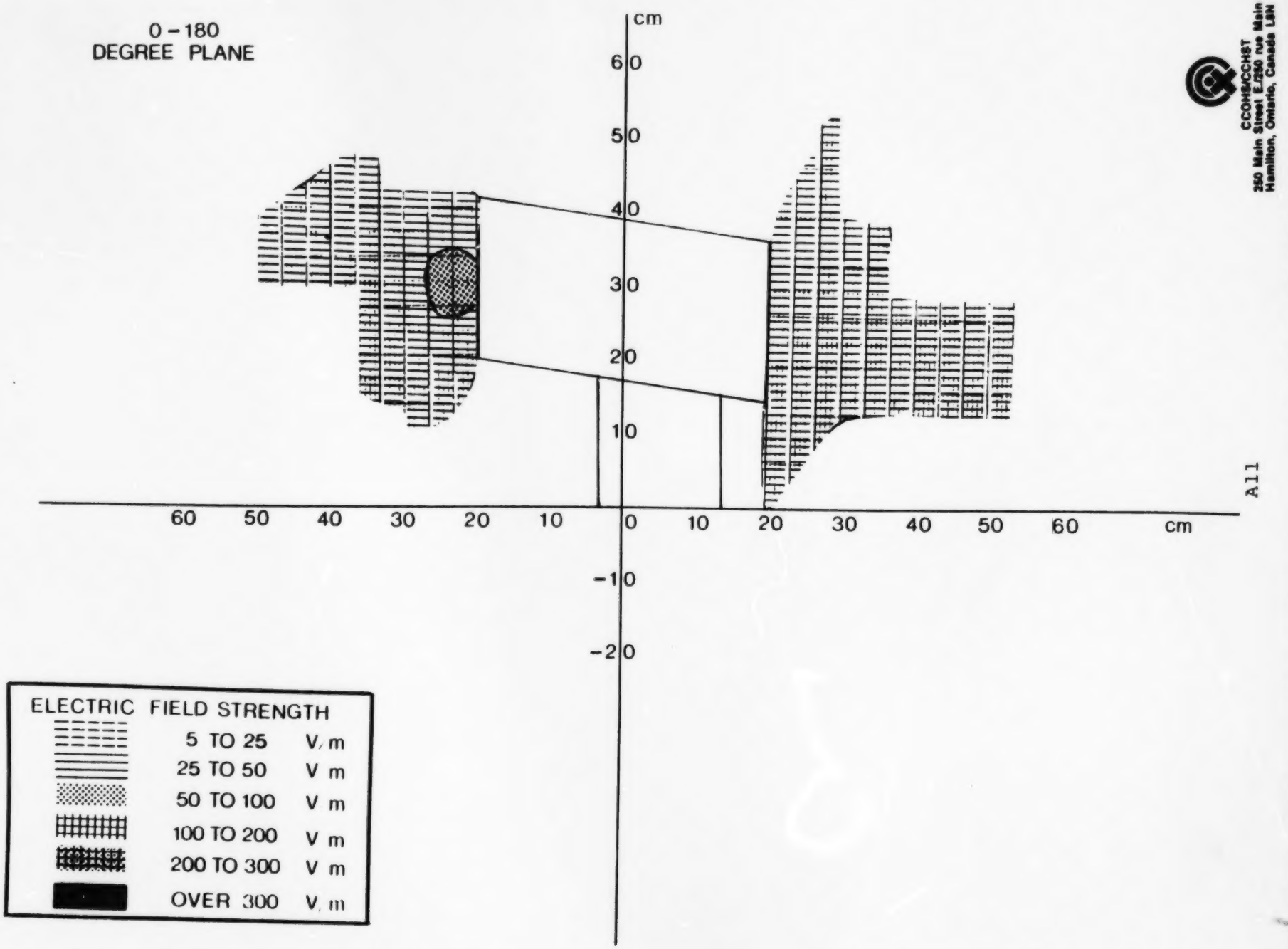
CCOHS/CCHST
250 Main Street E./250 rue Main est
Hamilton, Ontario, Canada L8N 1H6

CROSS-SECTIONAL VIEW OF VLF EMISSIONS

VERTICAL PLANE - HP2621P

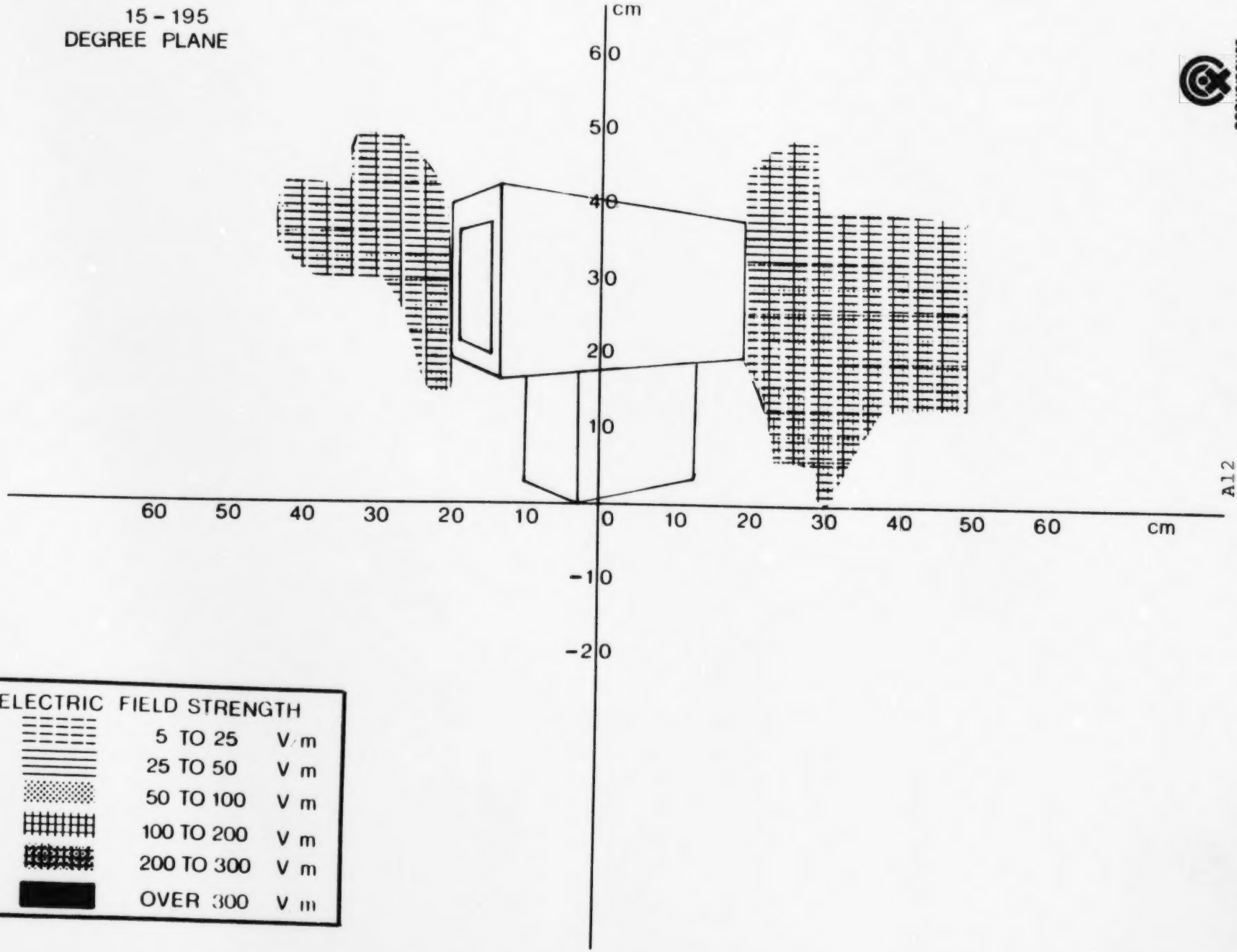
A11 to A17

CCOHS/CCHST
250 Main Street E./250 rue Main est
Hamilton, Ontario, Canada L8N 1H6



CCOHS/CCHST
250 Main Street E./250 rue Main est.
Hamilton, Ontario, Canada L8N 1H6

15 - 195
DEGREE PLANE



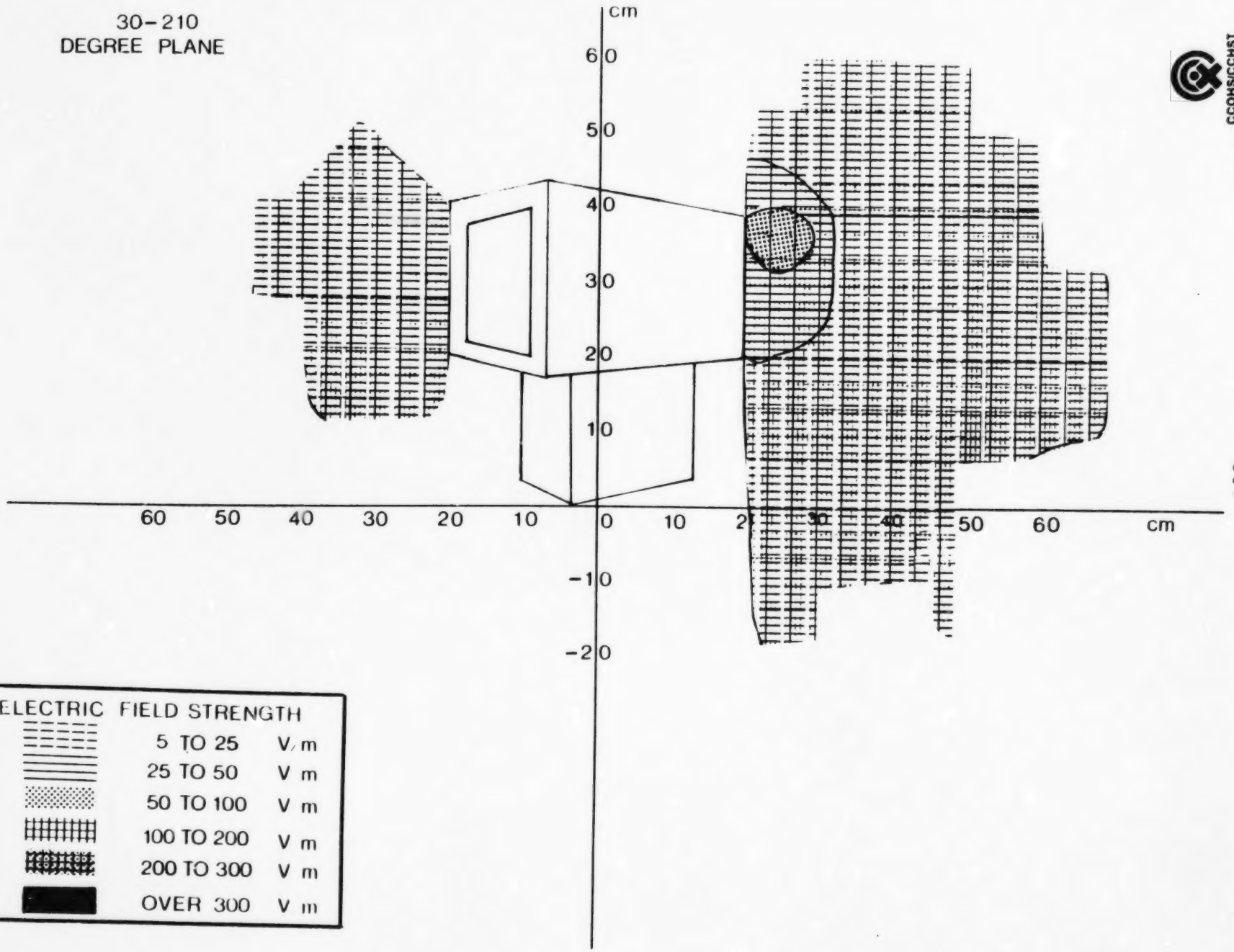
ELECTRIC FIELD STRENGTH

5 TO 25	V/m
25 TO 50	V m
50 TO 100	V m
100 TO 200	V m
200 TO 300	V m
OVER 300	V m

A12

CCOHS/CCHST
250 Main Street E./250 rue Main est.
Hamilton, Ontario, Canada L8N 1H6

30-210
DEGREE PLANE



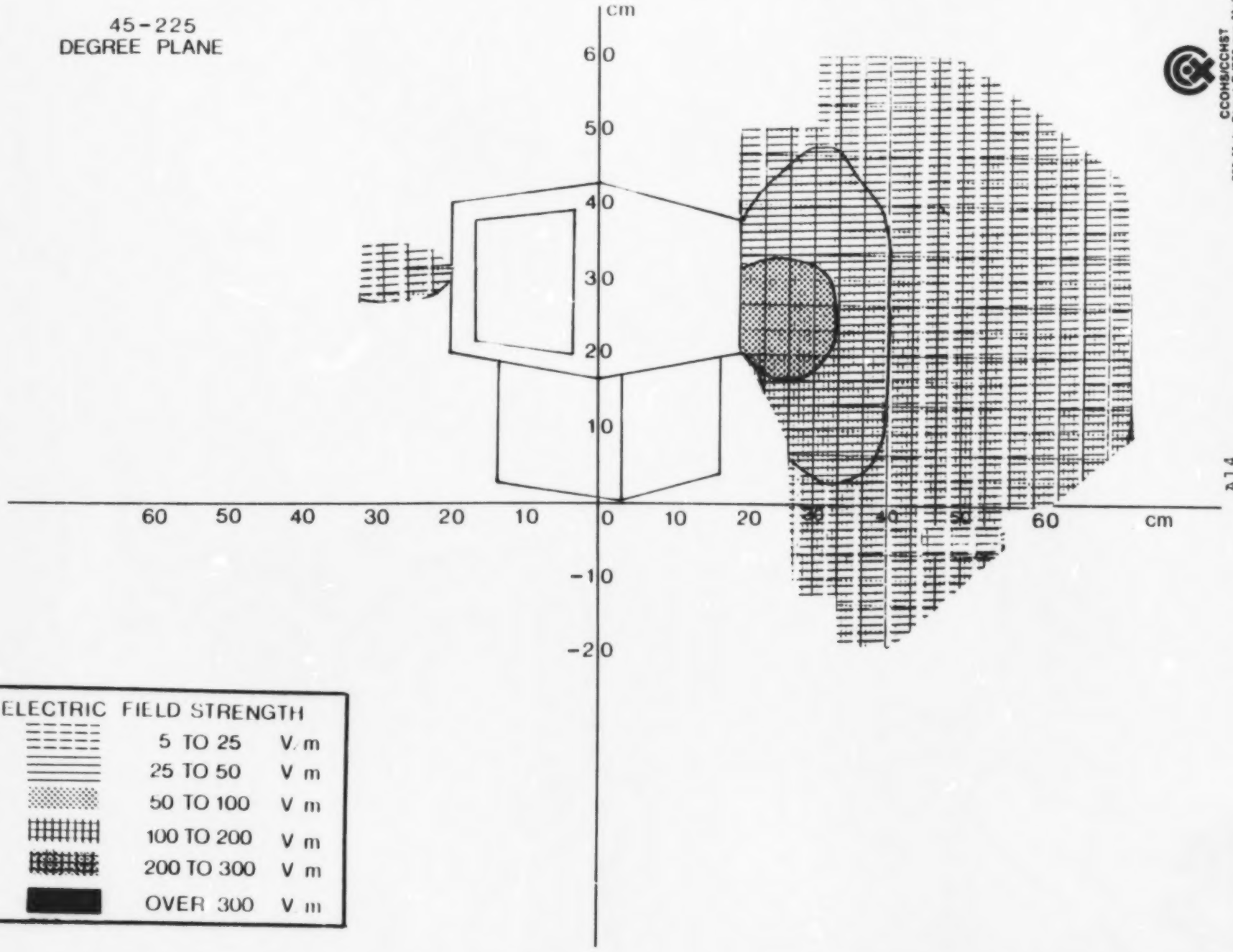
ELECTRIC FIELD STRENGTH

5 TO 25	V/m
25 TO 50	V m
50 TO 100	V m
100 TO 200	V m
200 TO 300	V m
OVER 300	V m

CCOHS/CCHST
250 Main Street E./250 rue Main est
Hamilton, Ontario, Canada L8N 1H6

A13

45-225
DEGREE PLANE



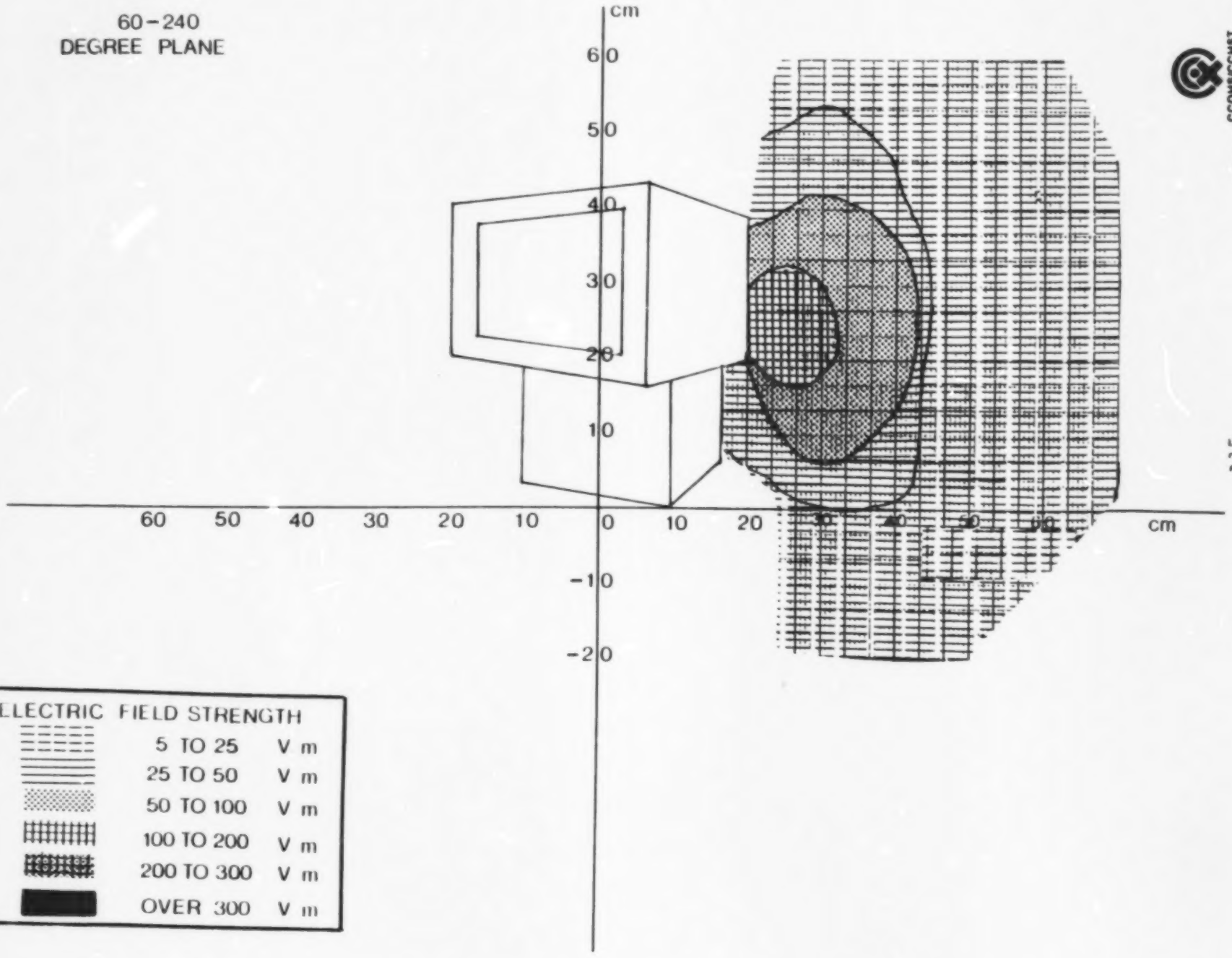
ELECTRIC FIELD STRENGTH

5 TO 25	V/m
25 TO 50	V m
50 TO 100	V m
100 TO 200	V m
200 TO 300	V m
OVER 300	V m

CCOHS/CCHST
250 Main Street E./250 rue Main est
Hamilton, Ontario, Canada L8N 1H6

A14

60-240
DEGREE PLANE



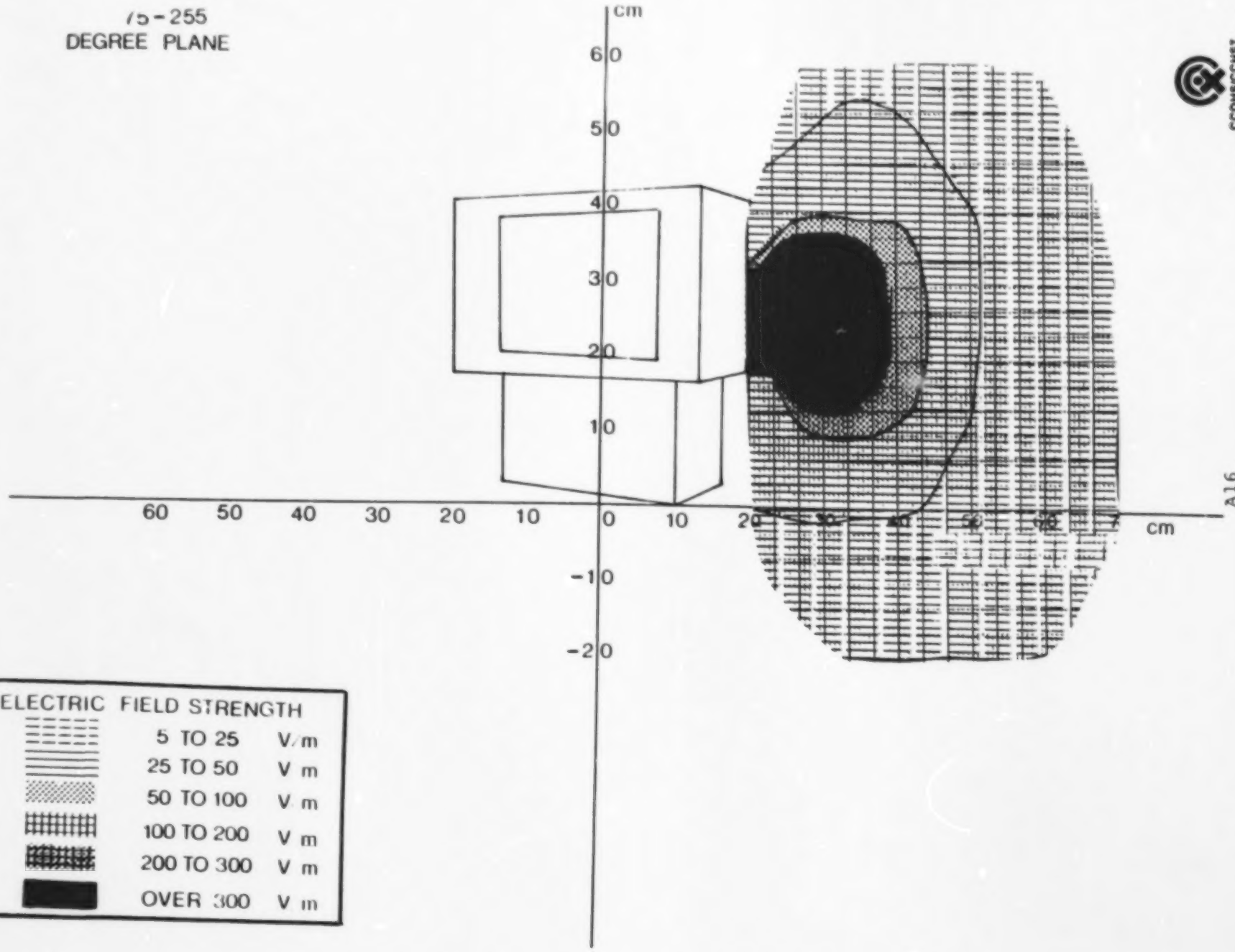
ELECTRIC FIELD STRENGTH

5 TO 25	V m
25 TO 50	V m
50 TO 100	V m
100 TO 200	V m
200 TO 300	V m
OVER 300	V m

CCOHS/CCHST
250 Main Street E./250 rue Main est.
Hamilton, Ontario, Canada L8N 1H6

A15

75-255
DEGREE PLANE



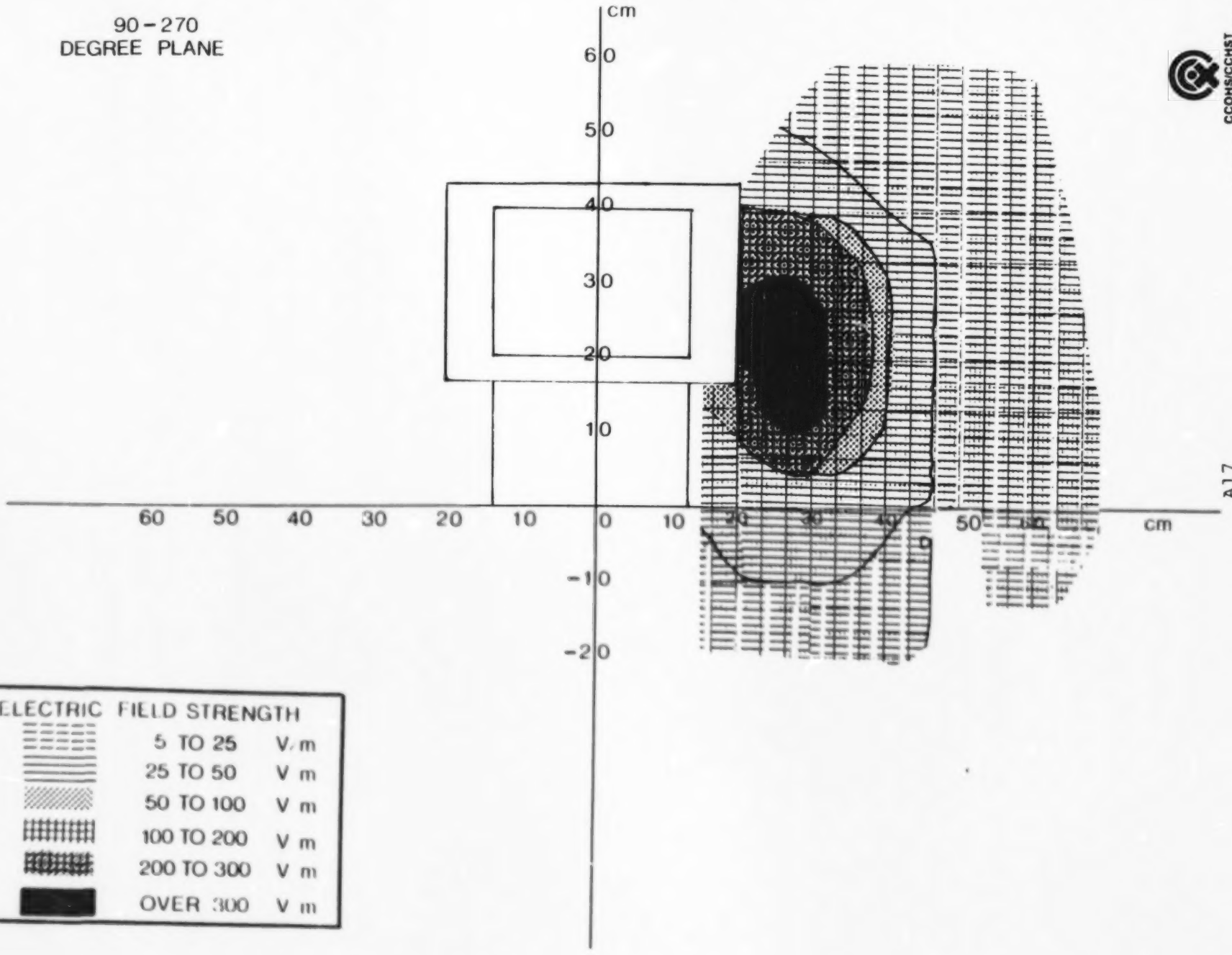
ELECTRIC FIELD STRENGTH

5 TO 25	V/m
25 TO 50	V m
50 TO 100	V m
100 TO 200	V m
200 TO 300	V m
OVER 300	V m

CCOHS/CCHST
250 Main Street E./250 rue Main est
Hamilton, Ontario, Canada L8N 1H6

A16

90 – 270
DEGREE PLANE



ELECTRIC FIELD STRENGTH

5 TO 25	V/m
25 TO 50	V m
50 TO 100	V m
100 TO 200	V m
200 TO 300	V m
OVER 300	V m

CCOHS/CCHST
250 Main Street E./250 rue Main est.
Hamilton, Ontario, Canada L8N 1H6

A17

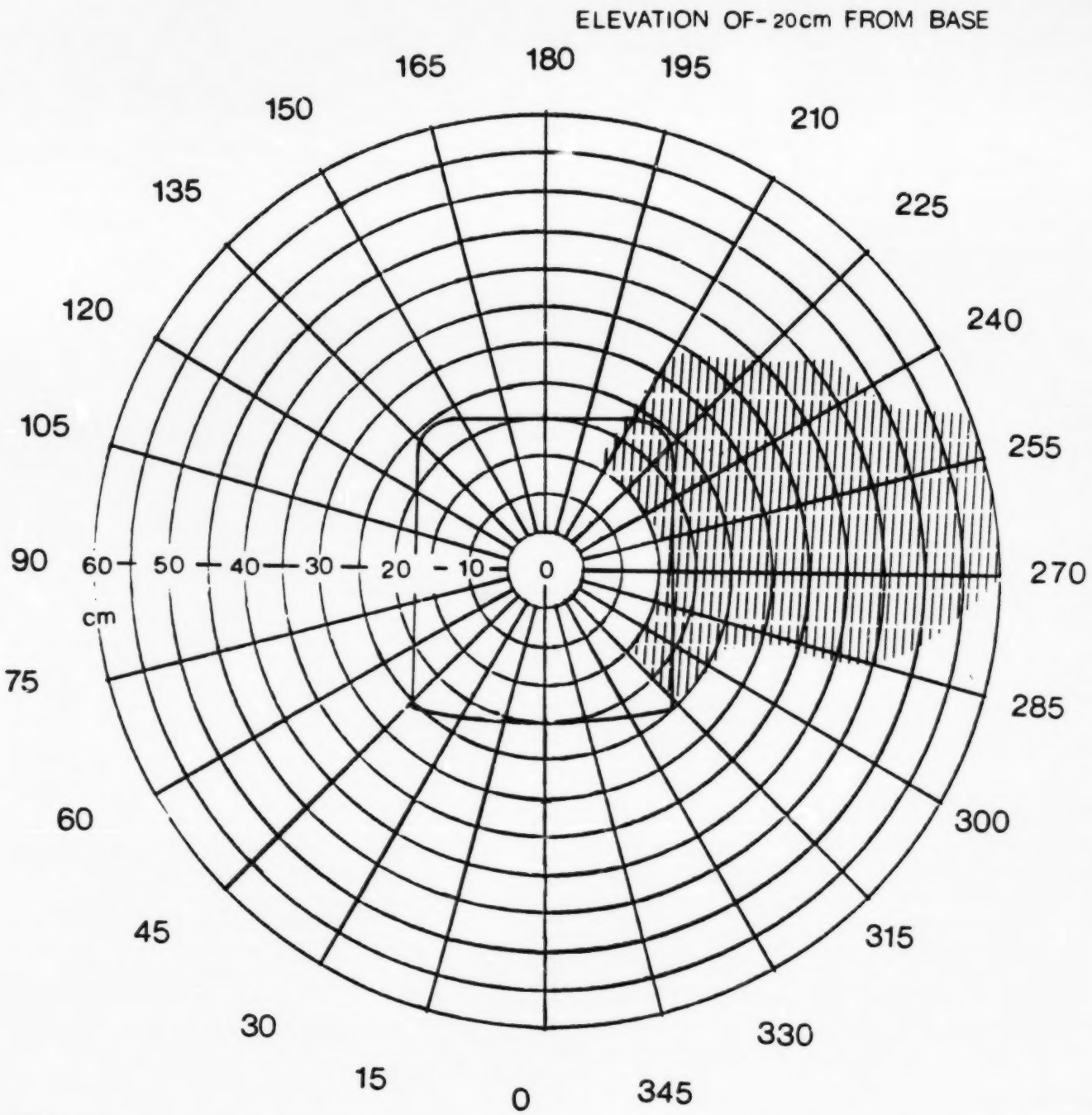
CROSS-SECTIONAL VIEW OF VLF EMISSIONS

HORIZONTAL PLANE - HP2621A

B1 to B10

CCOHS/CCHST
250 Main Street E./250 rue Main est
Hamilton, Ontario, Canada L8N 1H6

VLF ELECTRIC FIELD DISTRIBUTION AROUND HP-2621A VDT AT A CONSTANT ELEVATION - TOP VIEW

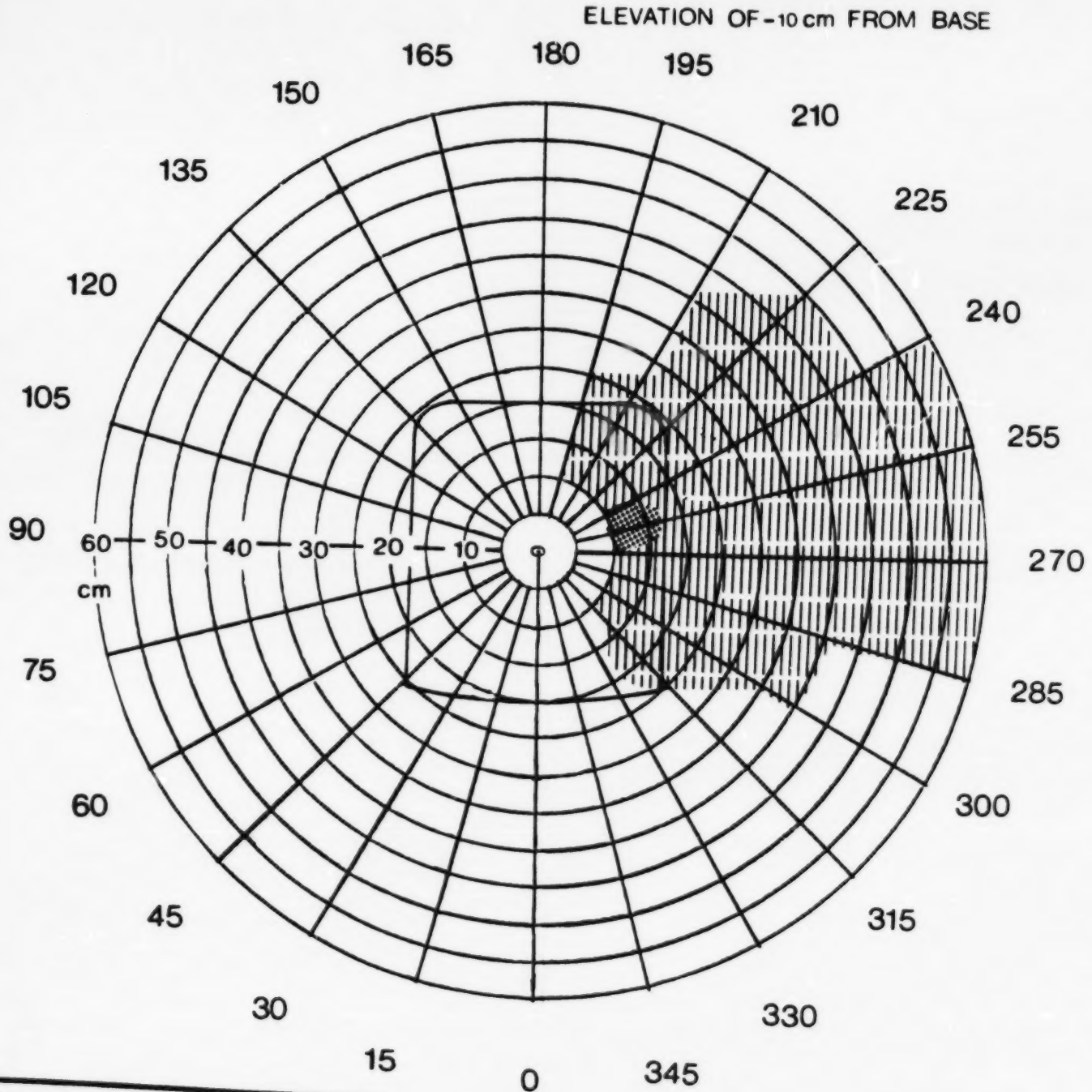


ELECTRIC FIELD STRENGTH

5 TO 25	V/m
25 TO 50	V m
50 TO 100	V m
100 TO 200	V m
200 TO 300	V m
OVER 300	V/m

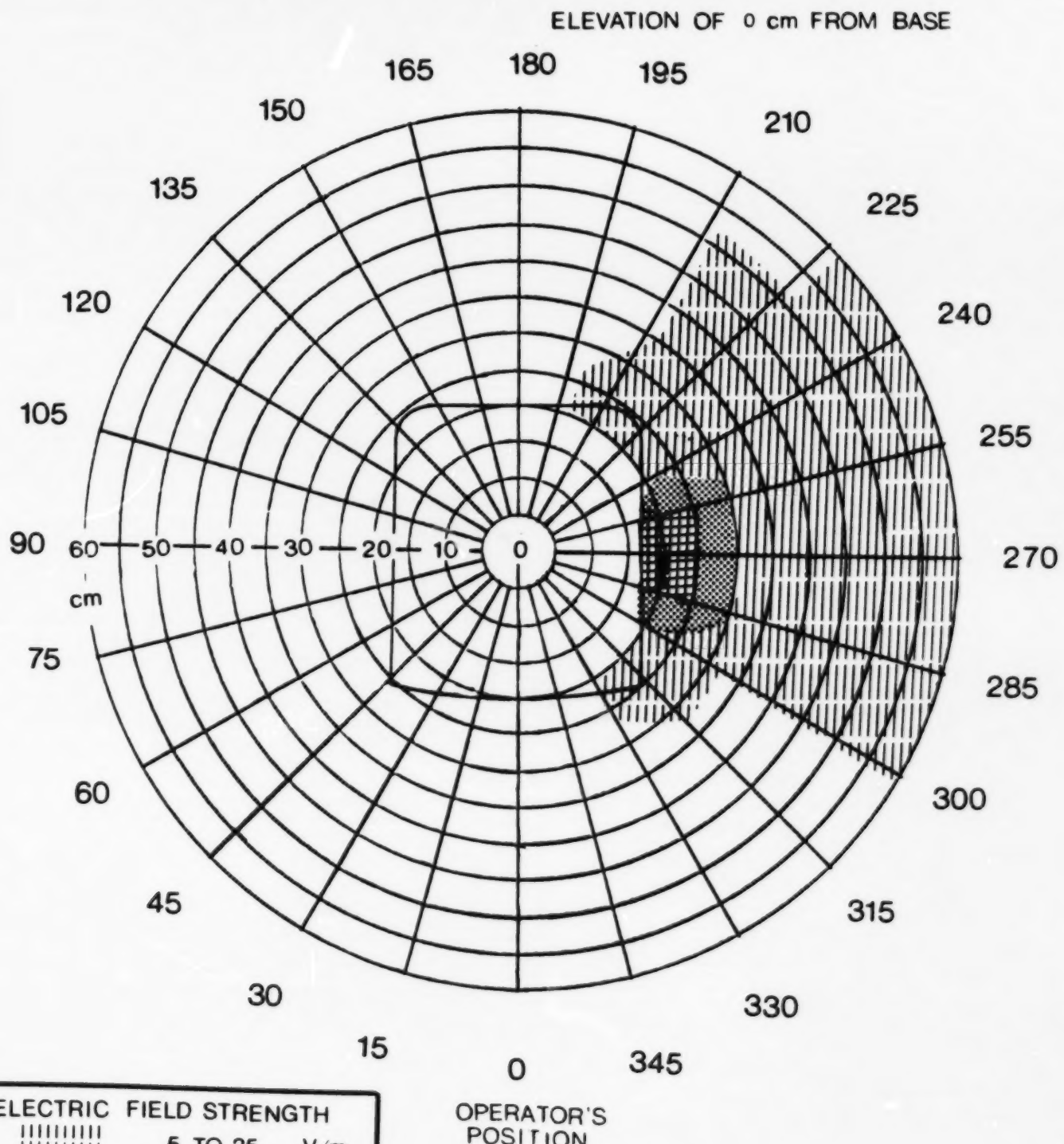
CCOHS/CCHST
250 Main Street E./250 rue Main est.
Hamilton, Ontario, Canada L8N 1H6

VLF ELECTRIC FIELD DISTRIBUTION AROUND HP-2621A VDT AT A CONSTANT ELEVATION - TOP VIEW



CCOHS/CCHST
250 Main Street E./250 rue Main est.
Hamilton, Ontario, Canada L8N 1H6

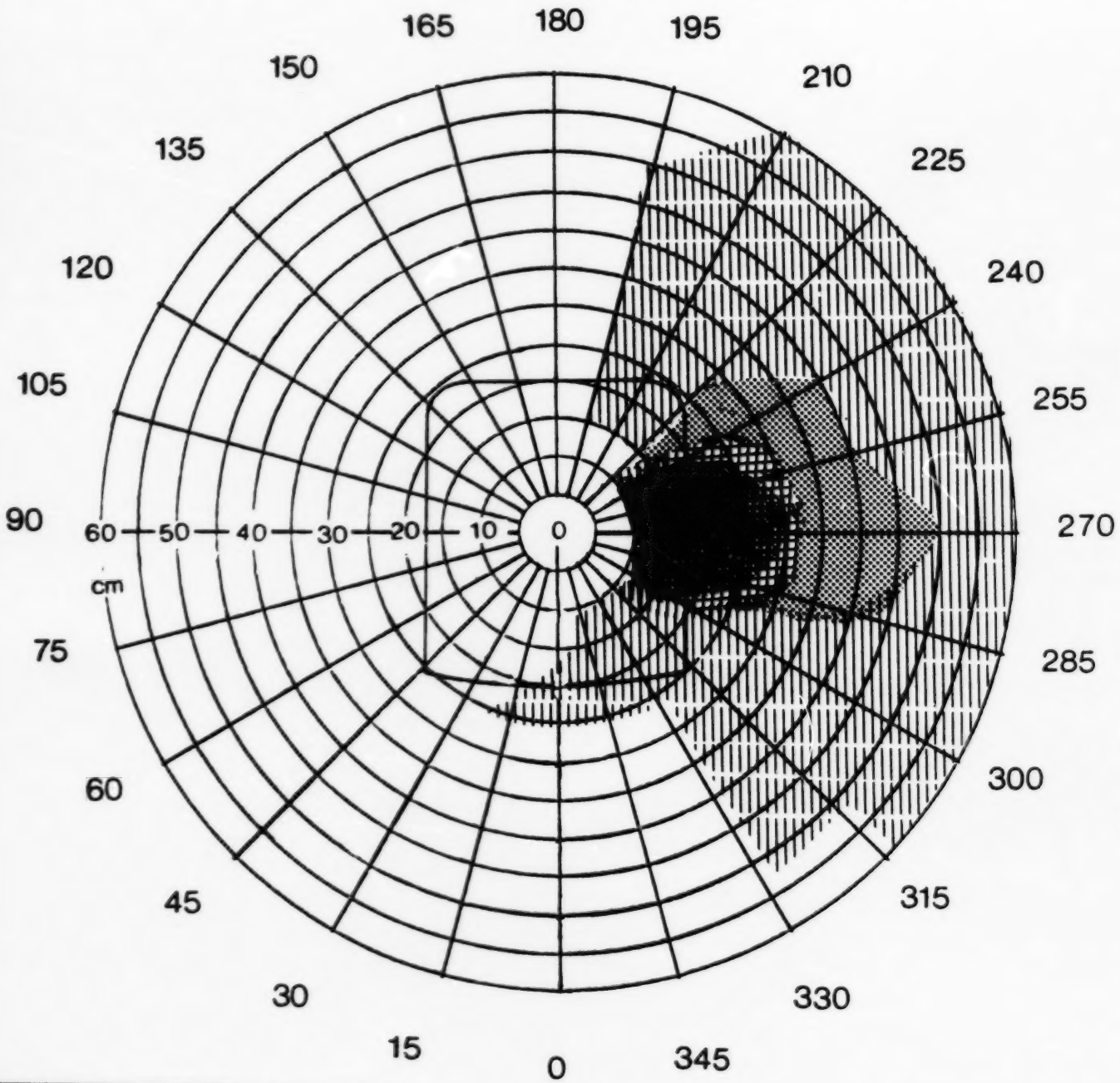
VLF ELECTRIC FIELD DISTRIBUTION AROUND HP-2621A VDT AT A CONSTANT ELEVATION - TOP VIEW



CCOHS/CCHST
250 Main Street E./250 rue Main est.
Hamilton, Ontario, Canada L8N 1H6

VLF ELECTRIC FIELD DISTRIBUTION AROUND HP-2621A VDT AT A CONSTANT ELEVATION - TOP VIEW

ELEVATION OF 10 cm FROM BASE



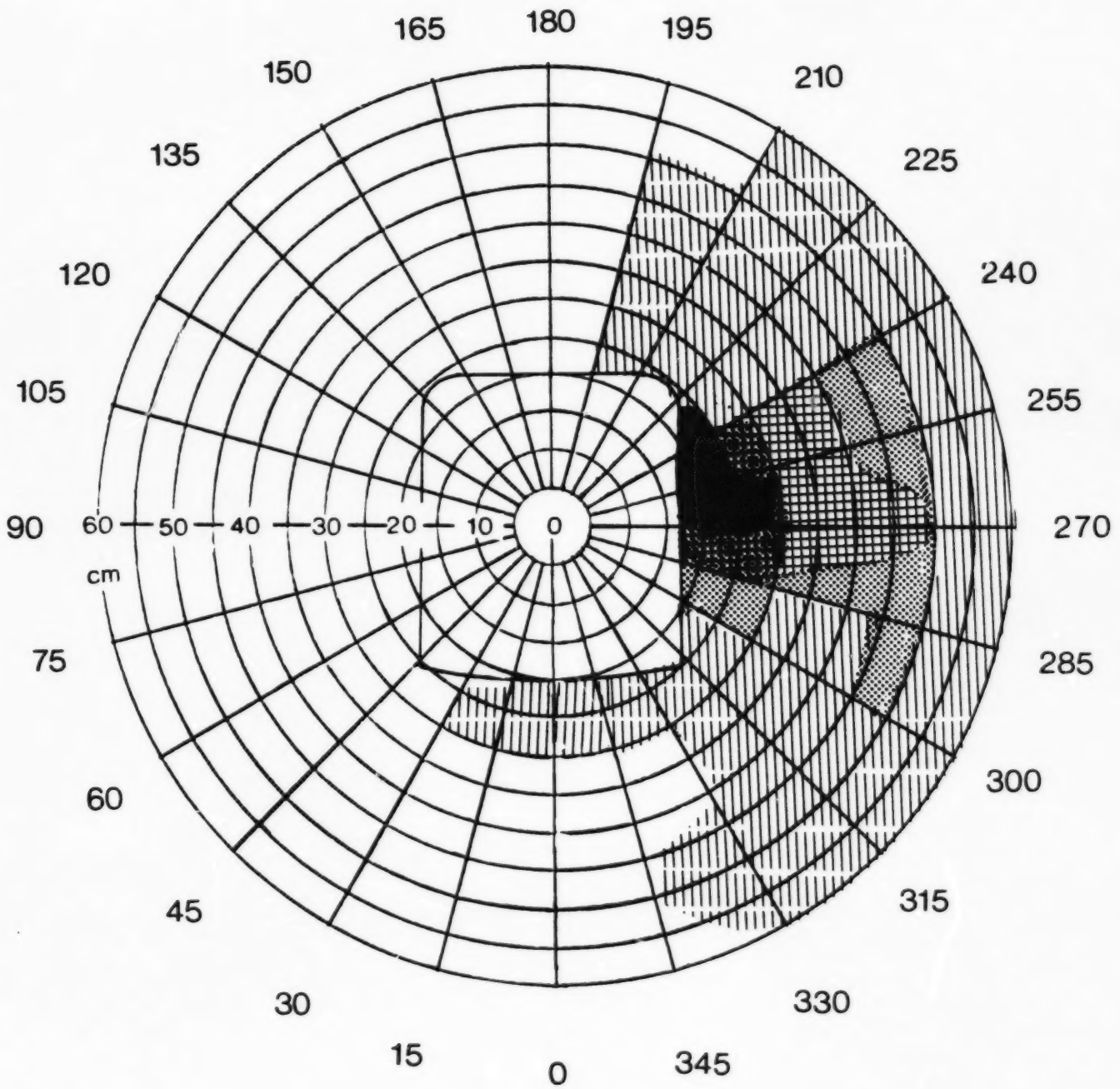
ELECTRIC FIELD STRENGTH

	5 TO 25	V/m
	25 TO 50	V m
	50 TO 100	V m
	100 TO 200	V m
	200 TO 300	V m
	OVER 300	V/m

OPERATOR'S POSITION

CCOHS/CCHST
250 Main Street E./250 rue Main est.
Hamilton, Ontario, Canada L8N 1H6

ELEVATION OF 20 cm FROM BASE



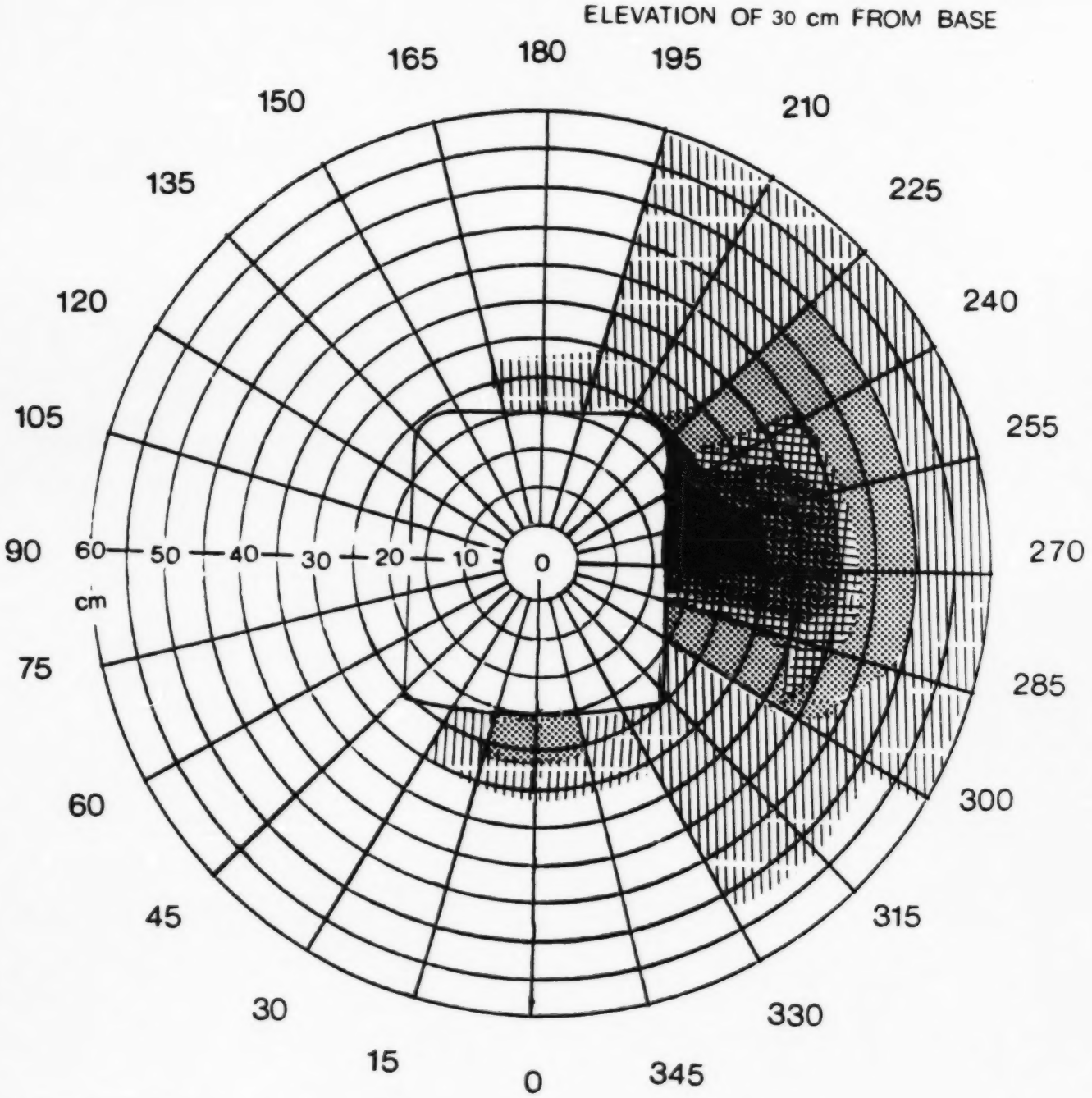
OPERATOR'S POSITION

ELECTRIC FIELD STRENGTH

5 TO 25	V/m
25 TO 50	V m
50 TO 100	V m
100 TO 200	V m
200 TO 300	V m
OVER 300	V/m

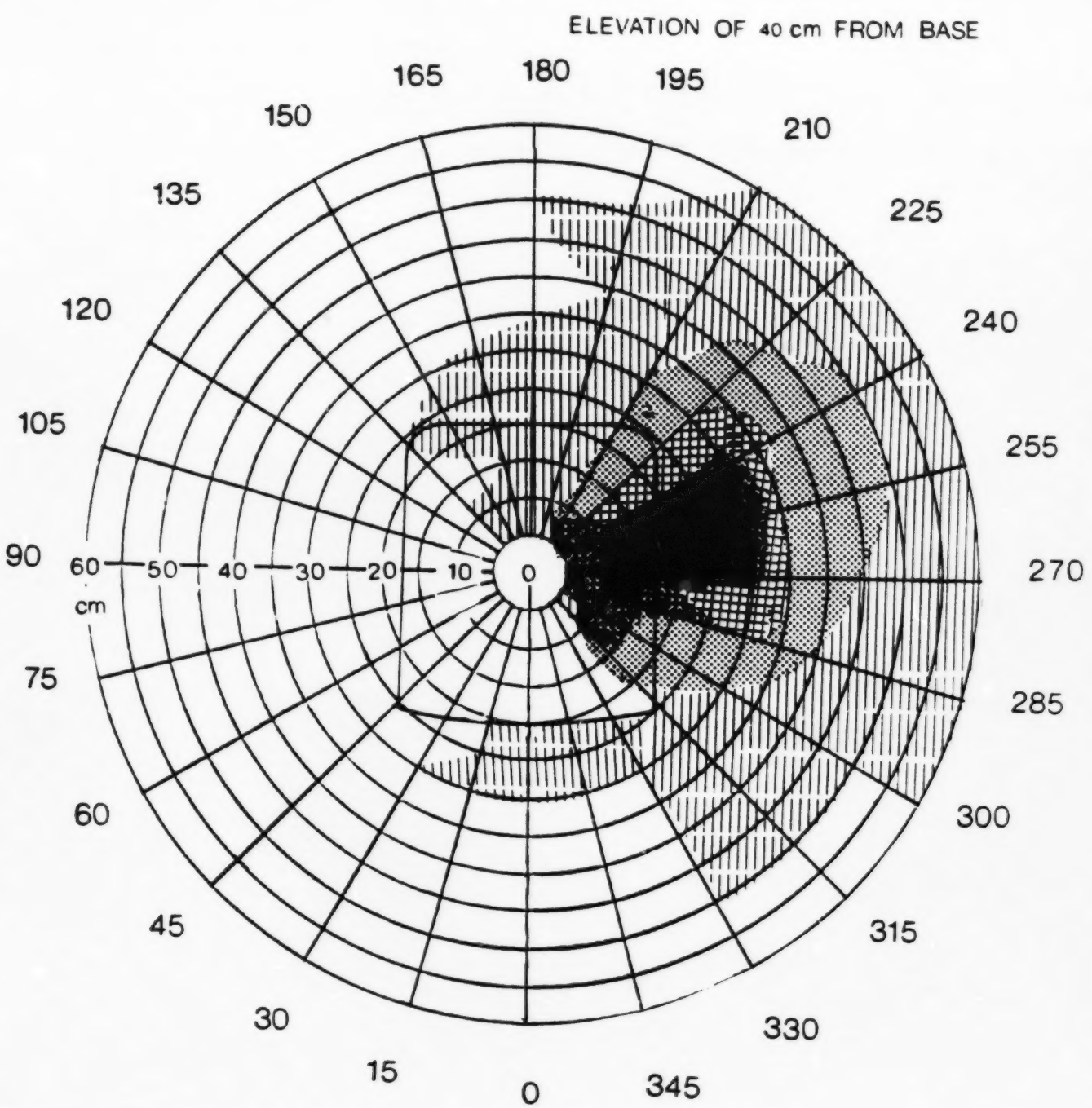
CCOHS/CCHST
250 Main Street E./250 rue Main est.
Hamilton, Ontario, Canada L8N 1H6

VLF ELECTRIC FIELD DISTRIBUTION AROUND HP-2621A VDT AT A CONSTANT ELEVATION - TOP VIEW



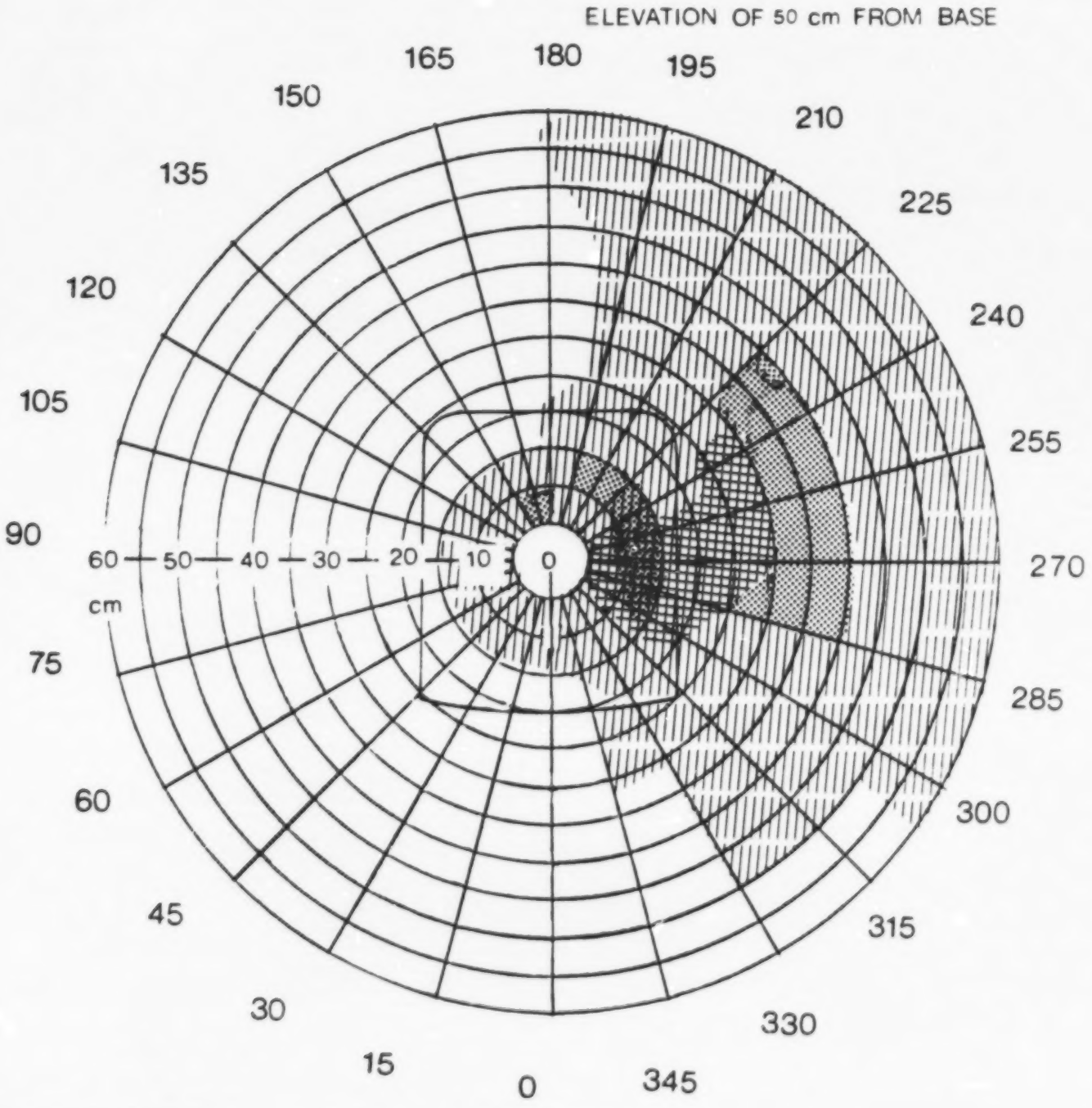
CCOHS/CCHST
250 Main Street E./250 rue Main est.
Hamilton, Ontario, Canada L8N 1H6

VLF ELECTRIC FIELD DISTRIBUTION AROUND HP-2621A VDT AT A CONSTANT ELEVATION - TOP VIEW



CCOHS/CCHST
250 Main Street E./250 rue Main est
Hamilton, Ontario, Canada L8N 1H6

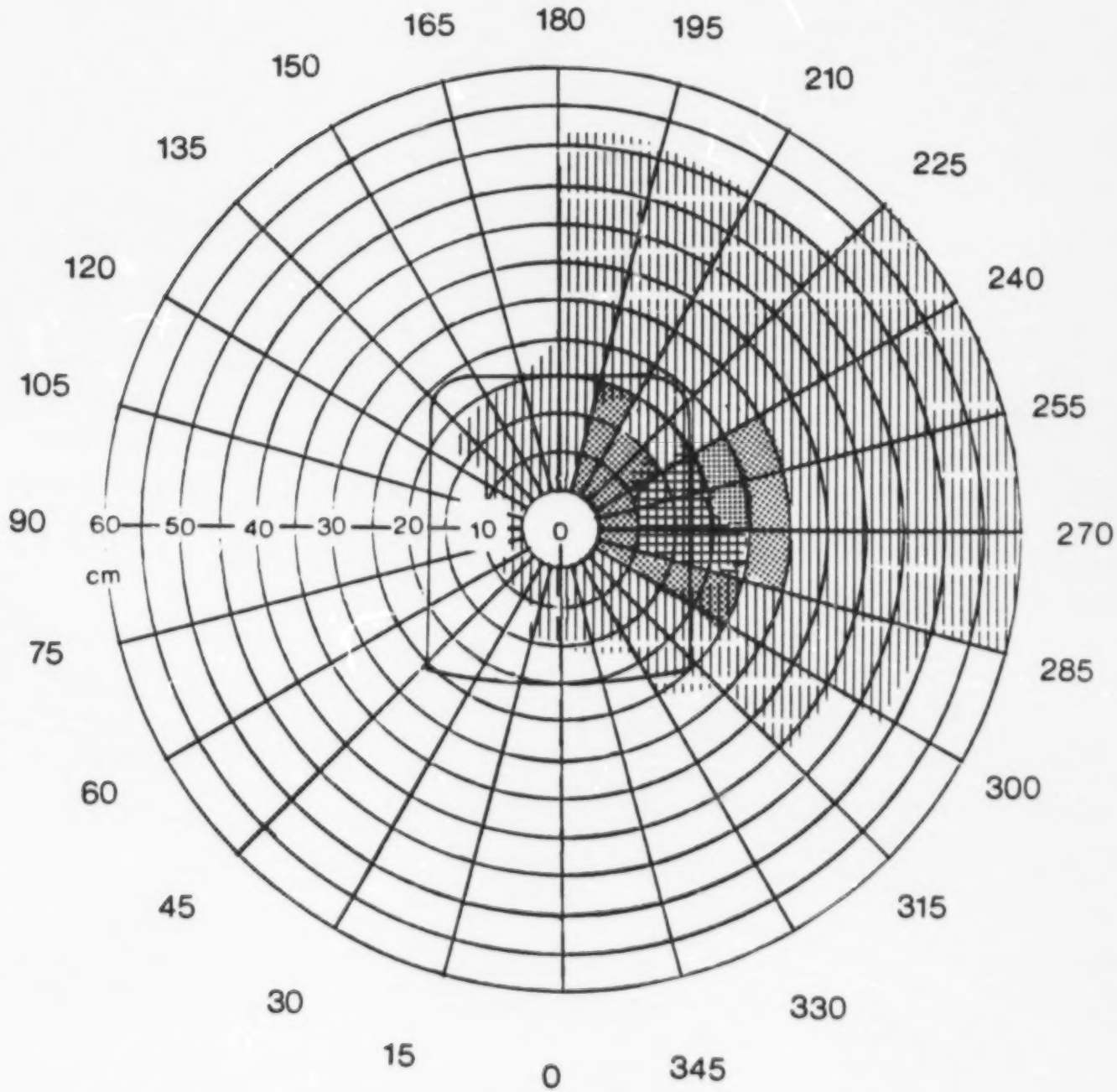
VLF ELECTRIC FIELD DISTRIBUTION AROUND HP-2621A VDT AT A CONSTANT ELEVATION - TOP VIEW



CCOHS/CCHST
250 Main Street E./250 rue Main est.
Hamilton, Ontario, Canada L8N 1H6

VLF ELECTRIC FIELD DISTRIBUTION AROUND HP-2621A VDT AT A CONSTANT ELEVATION - TOP VIEW

ELEVATION OF 60 cm FROM BASE



OPERATOR'S POSITION

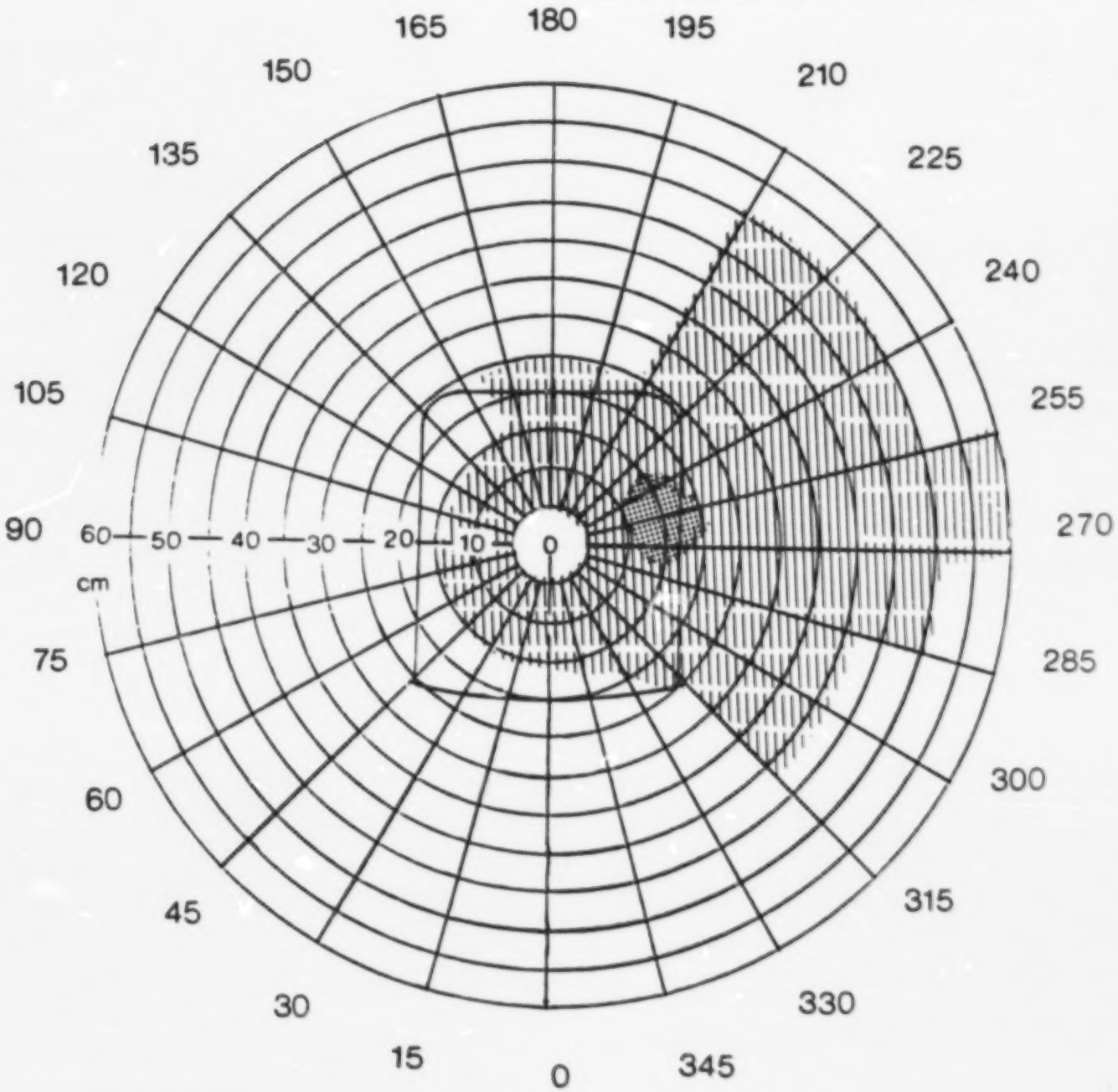
ELECTRIC FIELD STRENGTH		
	5 TO 25	V/m
	25 TO 50	V m
	50 TO 100	V m
	100 TO 200	V m
	200 TO 300	V m
	OVER 300	V m

By

CCOHS/CCHST
250 Main Street E./250 rue Main est.
Hamilton, Ontario, Canada L8N 1H6

VLF ELECTRIC FIELD DISTRIBUTION AROUND HP-2621A VDT AT A CONSTANT ELEVATION - TOP VIEW

ELEVATION OF 70 cm FROM BASE



OPERATOR'S POSITION

ELECTRIC FIELD STRENGTH

5 TO 25	V m
25 TO 50	V m
50 TO 100	V m
100 TO 200	V m
200 TO 300	V m
OVER 300	V m

CCOHS/CCHST
250 Main Street E./250 rue Main est
Hamilton, Ontario, Canada L8N 1H6

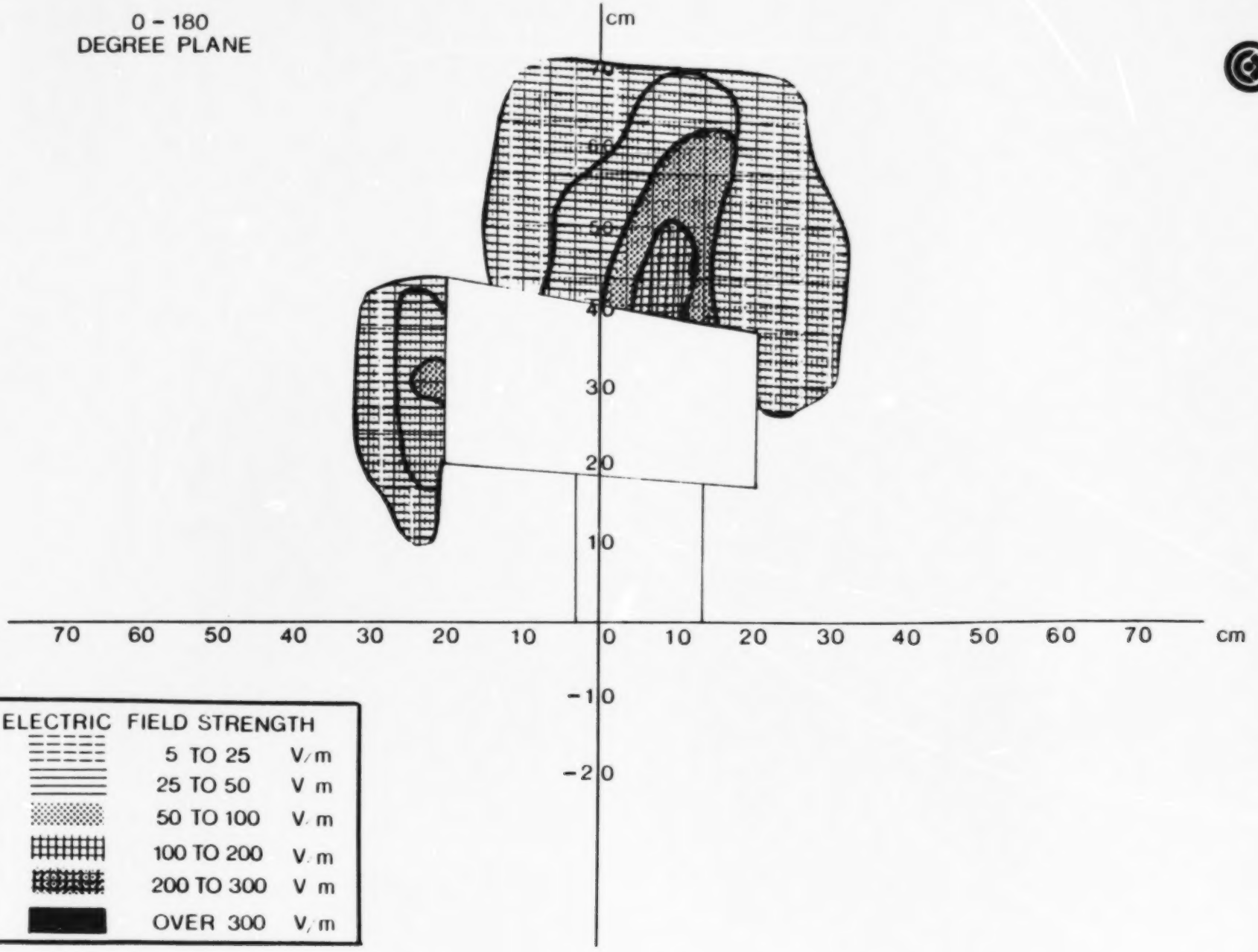
CROSS-SECTIONAL VIEW OF VLF EMISSIONS

VERTICAL PLANE - HP2621A

B11 to B17

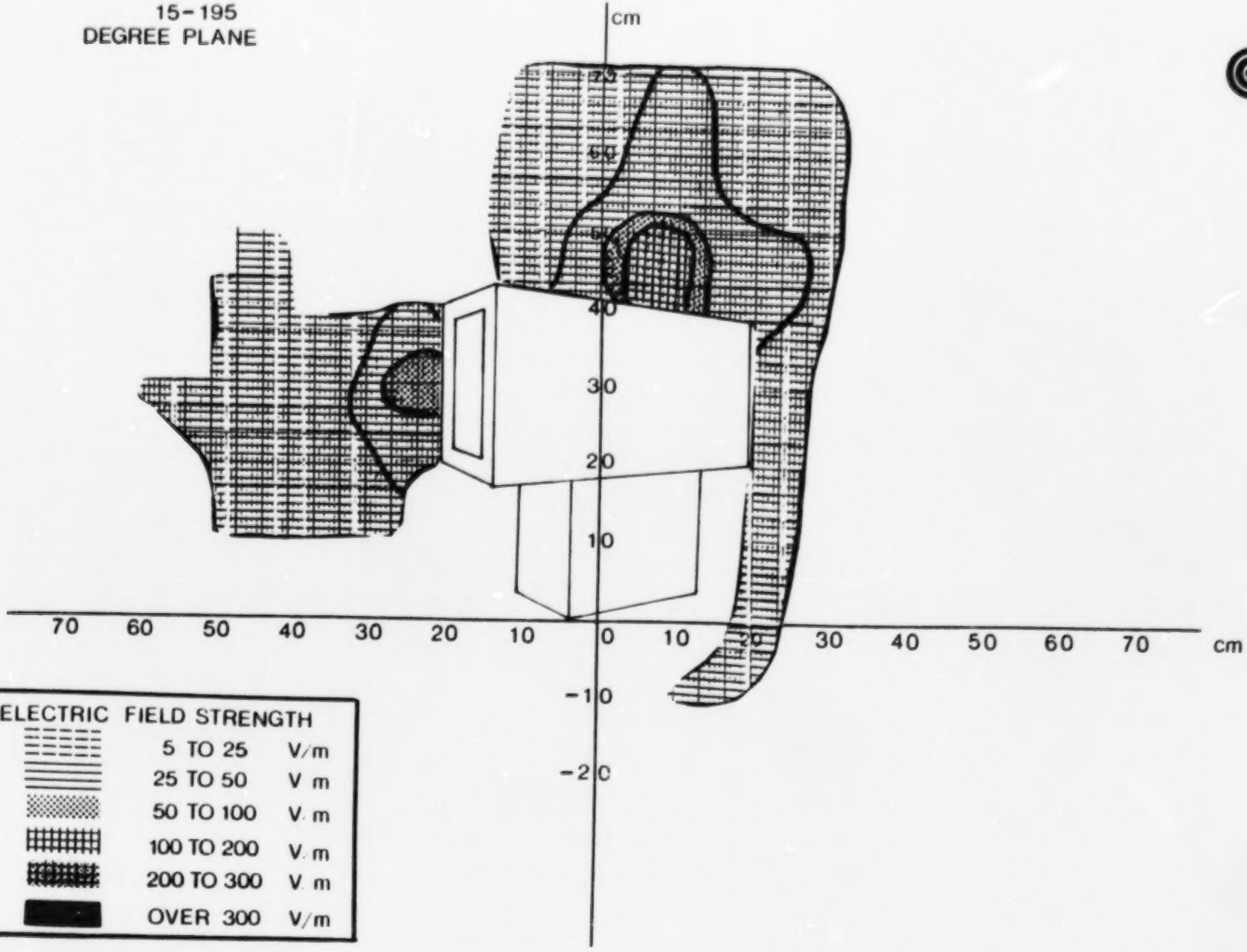
CCOHS/CCHST
250 Main Street E./250 rue Main est
Hamilton, Ontario, Canada L8N 1H6

0 - 180
DEGREE PLANE



CCOHS/CCHST
250 Main Street E./250 rue Main est.
Hamilton, Ontario, Canada L8N 1H6

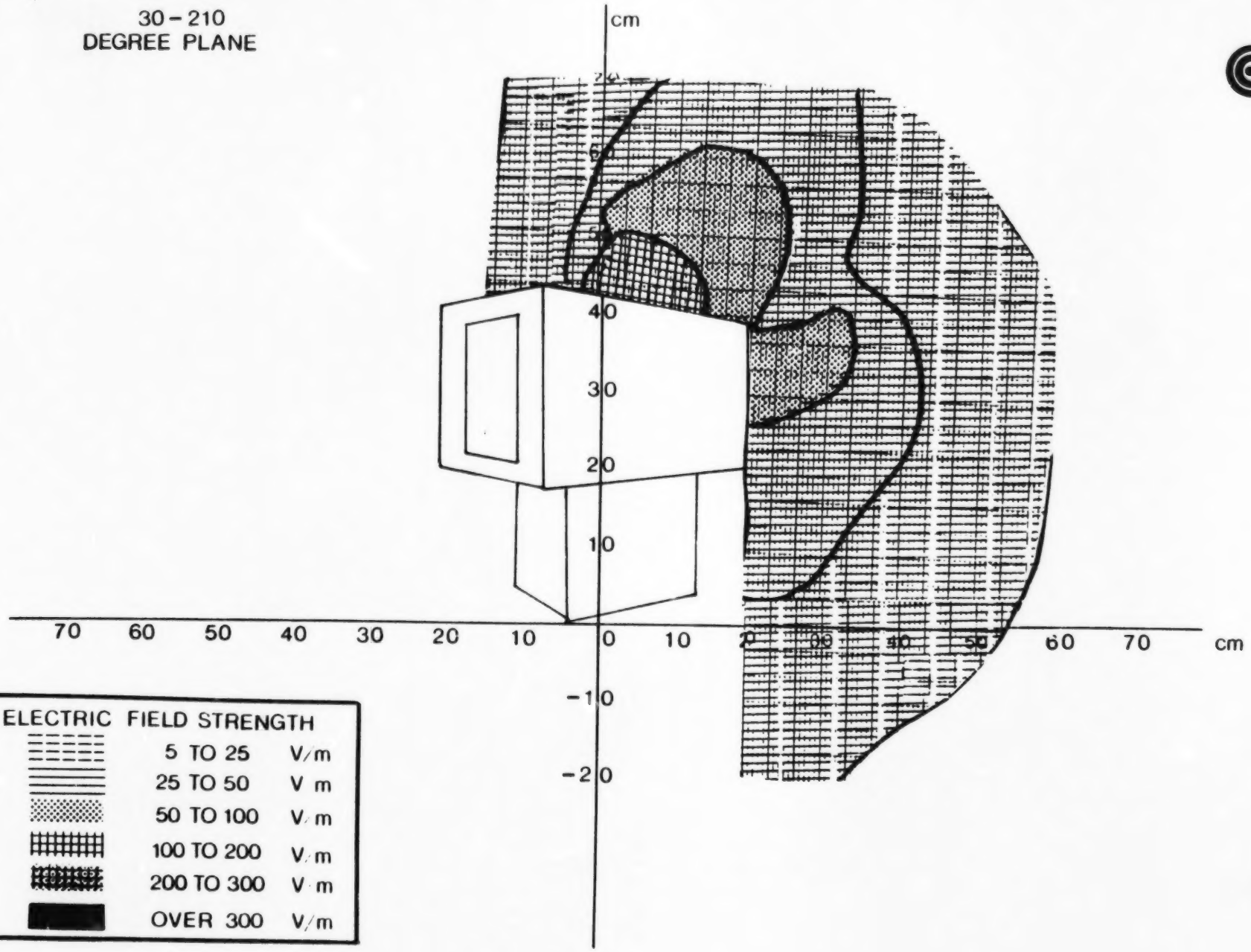
B11



CCOHS/CCHST
250 Main Street E./250 rue Main est.
Hamilton, Ontario, Canada L8N 1H6

B12

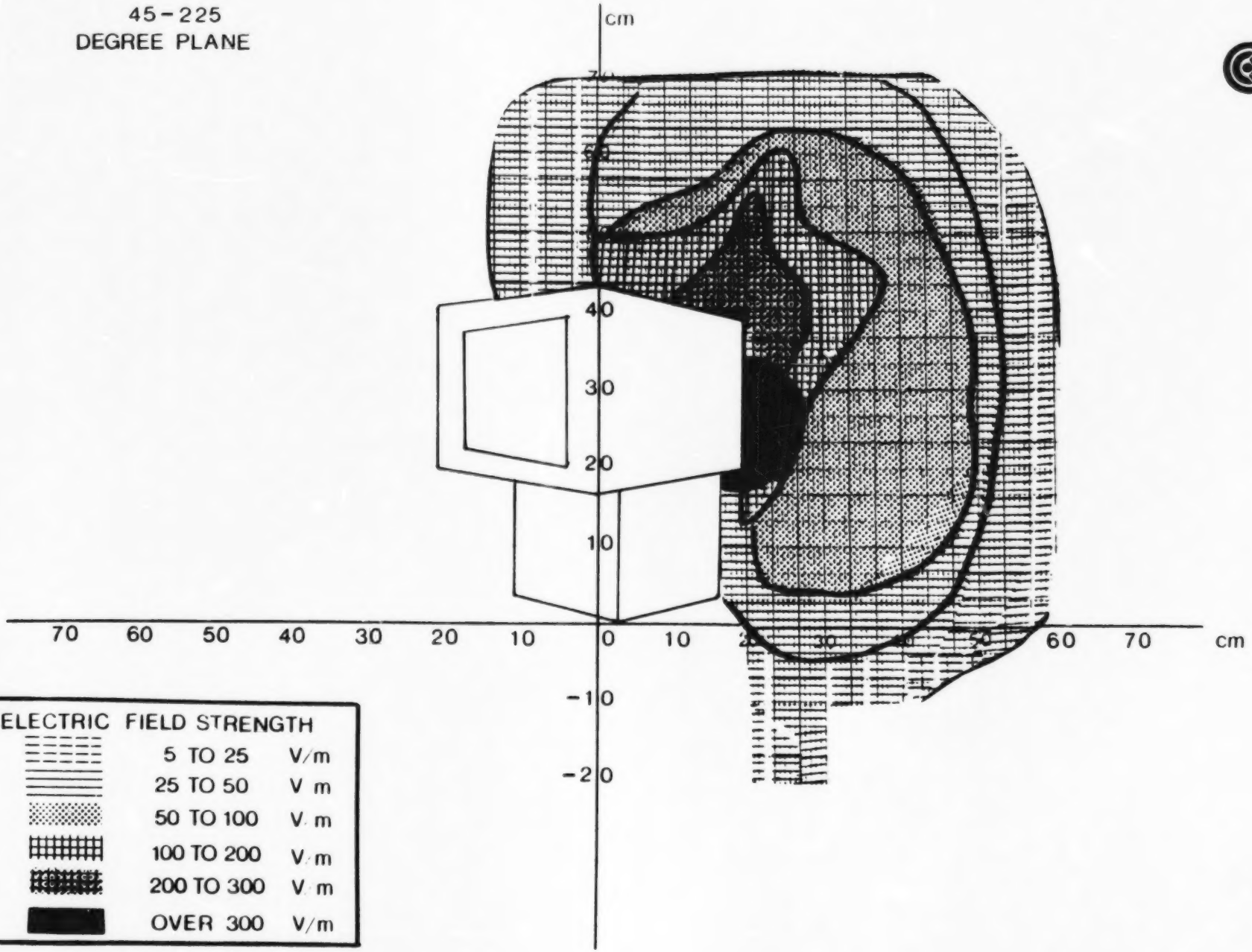
30 – 210
DEGREE PLANE



CCOHS/CCHST
250 Main Street E./250 rue Main est.
Hamilton, Ontario, Canada L8N 1H6

B13

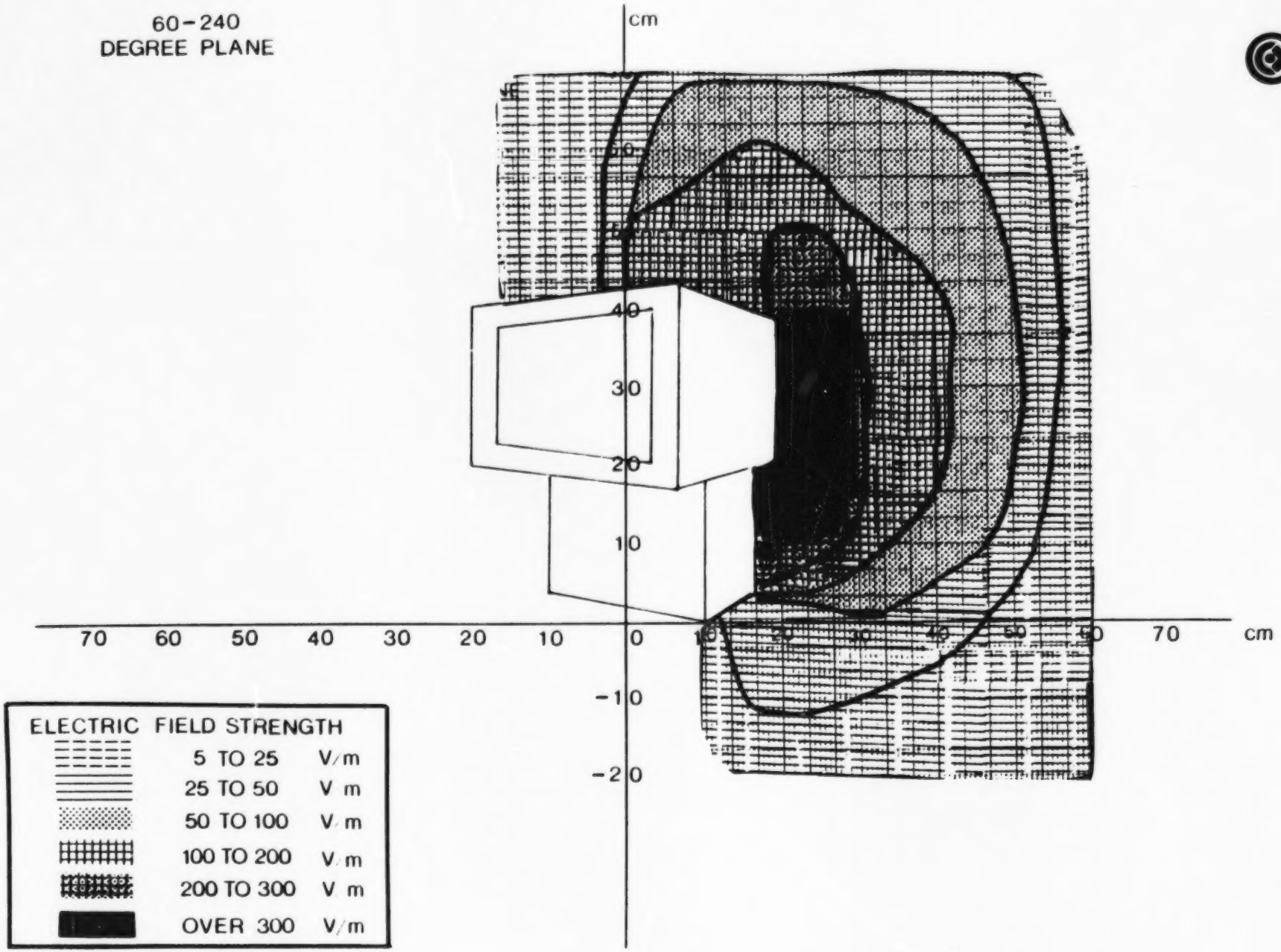
45 - 225
DEGREE PLANE



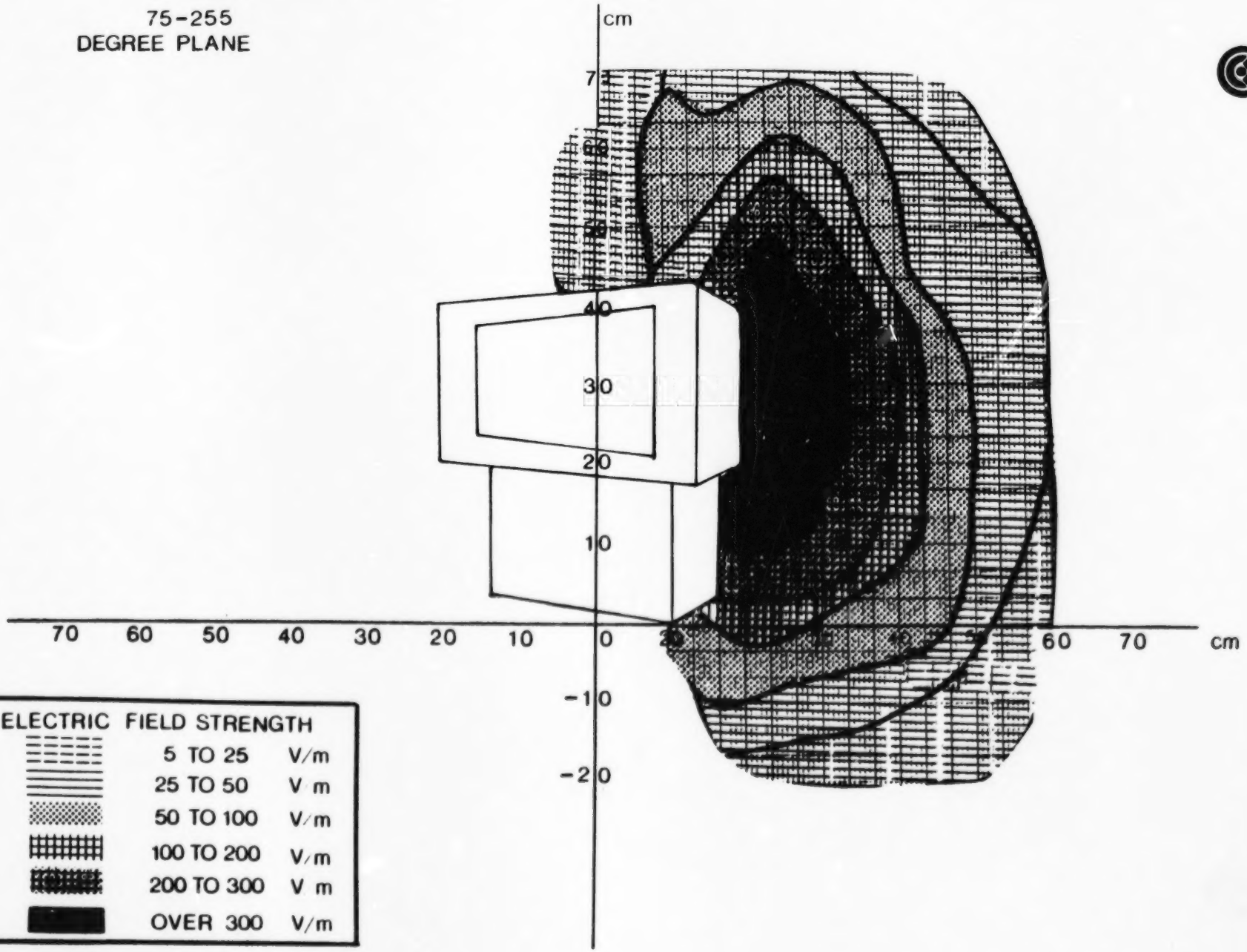
CCOHS/CCHST
250 Main Street E./250 rue Main est.
Hamilton, Ontario, Canada L8N 1H6

B14

60-240
DEGREE PLANE

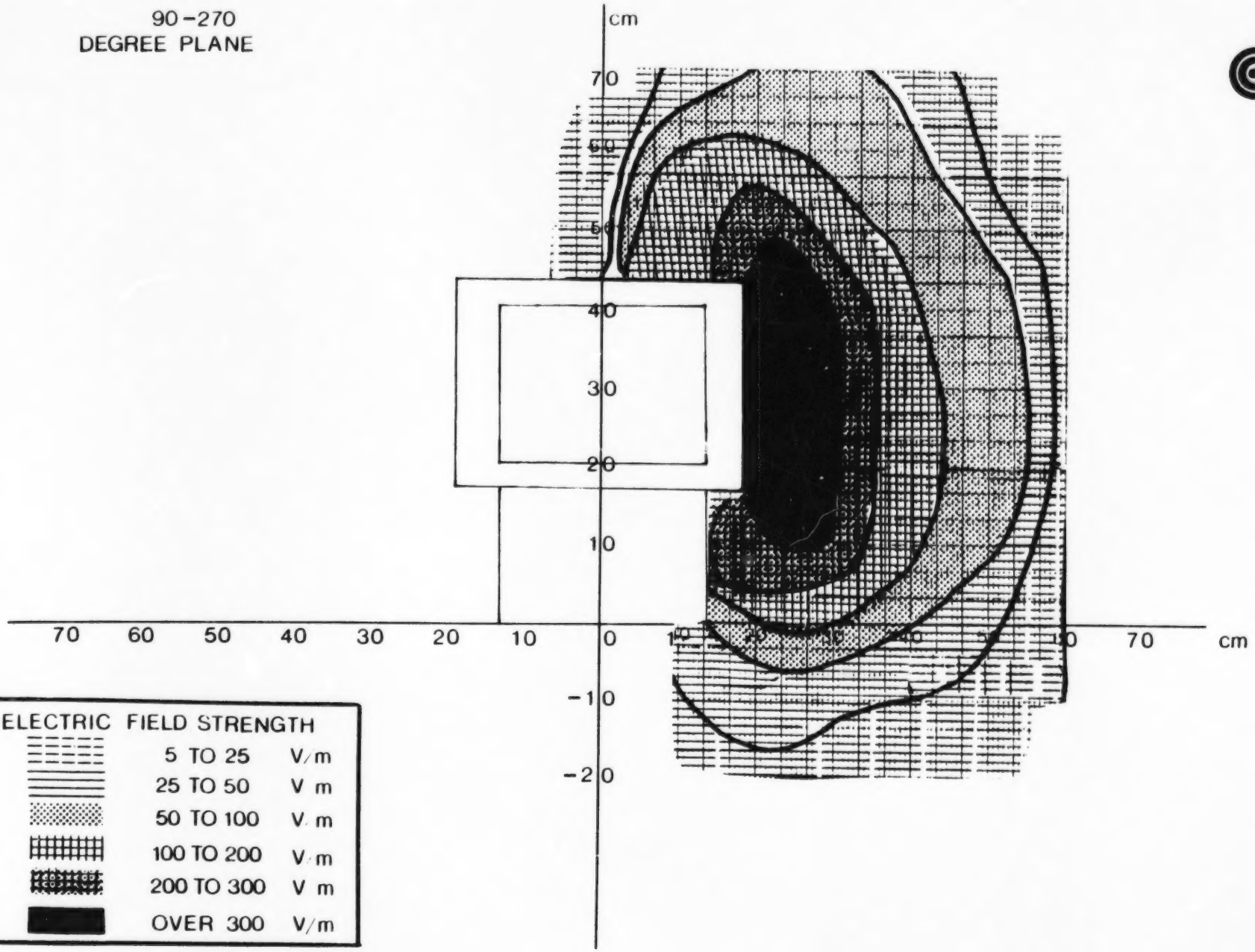


CCOHS/CCHST
250 Main Street E./250 rue Main est.
Hamilton, Ontario, Canada L8N 1H6



CCOHS/CCHST
250 Main Street E./250 rue Main est
Hamilton, Ontario, Canada L8N 1H6

90-270
DEGREE PLANE



CCOHS/CCHST
250 Main Street E./250 rue Main est.
Hamilton, Ontario, Canada L8N 1H6

B17

PHOTOGRAPHS OF EXPERIMENTAL SHIELDING

APPENDIX C

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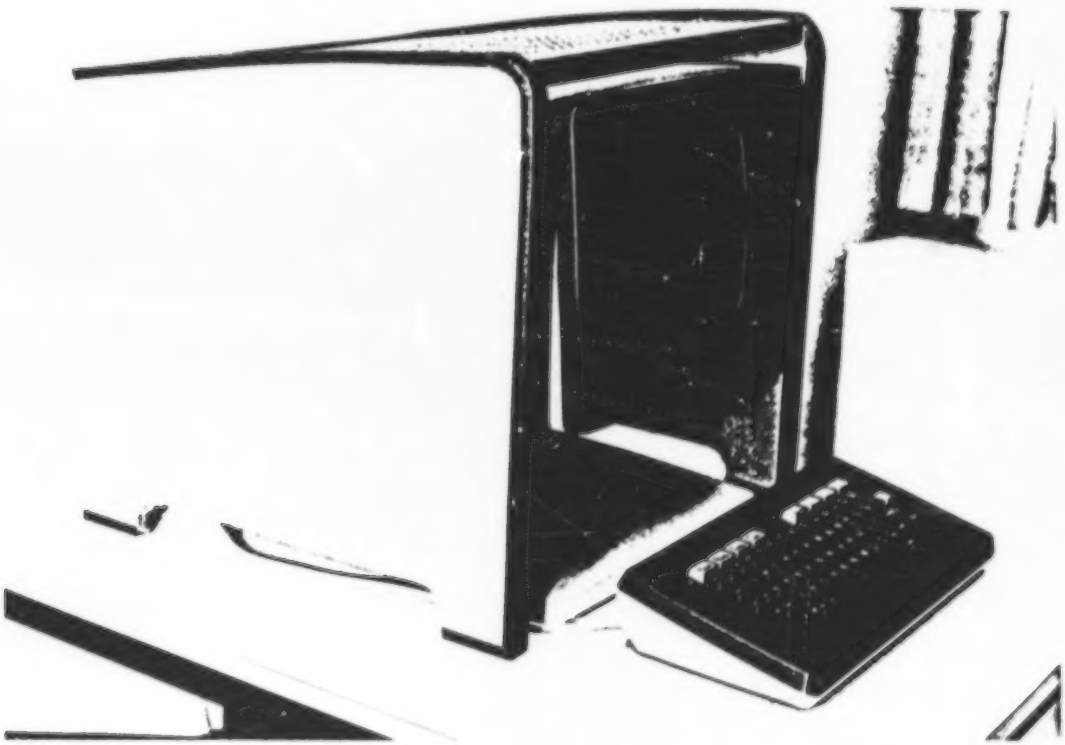
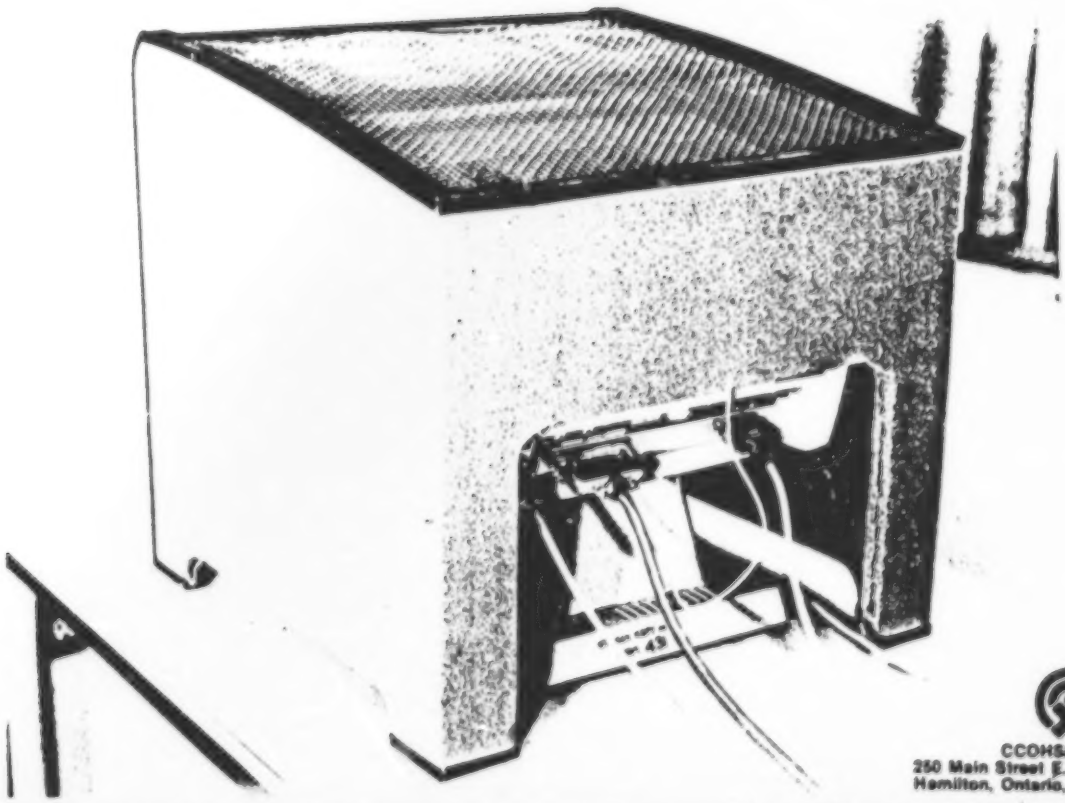
Photographs of Experimental Shielding





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